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SIC-Based Demand Information System for Nonfuel Minerals

By George K. Schenck, Balakrishnan K. Nair,
and Kung-Lee Wang

UNITED STATES DEPARTMENT OF THE INTERIOR

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UNITED STATES DEPARTMENT OF THE INTERIOR
James G. Watt, Secretary

BUREAU OF MINES
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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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PREFACE

This report was prepared by The Pennsylvania State University, Department of Mineral Economics, University Park, Pa., under USBM grant number G0166213. The grant was initiated under the Research and Development Program. It was administered under the technical direction of the Bureau's Economic Analysis Branch with K. L. Wang acting as Technical Project Officer. Joseph Pettus was the grant administrator for the Bureau of Mines. This report is a summary of the work completed as a part of this grant during the period February 1 to June 30, 1979. This report was submitted by the authors on June 30, 1979.

The research leading to the new data system was initiated by Dr. John Morgan, Chief Staff Officer and former Associate Director--Minerals and Metals Supply/Demand Analysis of the Bureau of Mines. Paul Meadow, former Director, Division of Analytic Studies, actively encouraged the work and made available the resources of his division. The valued cooperation of the commodity specialists for the minerals studied and the staff of the Division of Production/Consumption Data Collection and Interpretation was most essential to the project. Carl H. Cotterill, Director, Division of Field Operation and former Assistant Director--Metals, Minerals and Materials, strongly supported the implementation of this research and encouraged the Bureau's commodity specialists on his staff to cooperate fully on this project. Dr. William A. Vogely, Head of Pennsylvania State University's Department of Mineral Economics, provided important advice and guidance, and Frederick Demler, Thomas Majcher, William Nagle, and Robert Whelan conducted case studies. Encouragement and active help were provided by many people in the industry. Although space does not permit acknowledging each participant by name, the authors wish to thank all representatives of the firms and trade associations listed in appendix A for their assistance. Appendix B provides a list of the commodities studied and a guide to the project report in which the end-use survey for each commodity is discussed in detail.

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SIC-BASED DEMAND INFORMATION SYSTEM FOR NONFUEL MINERALS[1]

By George K. Schenck,[2] Balakrishnan K. Nair,[3] and Kung-Lee Wang[4]

ABSTRACT

This Bureau of Mines publication describes and evaluates a Standard Industrial Classification (SIC) based end-use data system for minerals that is designed to link the demand for minerals to economic activity in commercial uses.

The new data system is two-dimensional. The first dimension of technical product classes (TPC's) measures the consumption of minerals in major primary intermediate products. The second dimension measures the consumption of these TPC's in SIC end-use sectors in sufficient detail to identify the major determinants of demand for each TPC. Intercommodity comparisons are achieved at the level of SIC two-digit major groups. The methodology was developed so that all available sources of information from Government and industry can be utilized at minimum cost. This information will be supplemented with additional data to be obtained by modifying existing Bureau of Mines canvasses so as to elicit additional quantitative responses from mineral producers.

The new data system is expected to improve significantly the ability to forecast demand for minerals, and provide an information base that would, for the first time ever, permit resolution of such questions as trends in substitution among materials and the intensity-of-use of materials in end-use sectors. For the 42 TPC's identified in the report, data are available for the new system from current sources or, except for three TPC's that require new canvasses, can be obtained by modification of existing Bureau canvasses.

[1]The term "mineral" is used in this report in its broad, generic sense which encompasses such diverse mineral-based materials as elements, metals alloys, compounds, and commodities.

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INTRODUCTION

The SIC categorizes establishments by their major economic activities, qualified somewhat by product specialization. The choice of SIC to define end-use sectors in the Bureau of Mines mineral data system satisfies the primary objective of the data system; namely, to link the demand for minerals to (1) economic activity and (2) other Government data sources.

Public policy is now hampered by a lack of reliable information regarding the role of minerals in the economy, particularly their effect in specific end-use markets. How far is the economy dependent on the availability of minerals; what sectors of the economy are relatively more vulnerable to mineral shortages than other sectors; which of the minerals are more critical? These are all questions relevant to current public policy as it is addressed to the adequacy of materials for sustained economic growth. The new data base discussed in this report is meant to correct the void that now exists in the information needed for establishing policy to resolve the above issues.

Information is not static. Public policy not only demands information but also creates the demand for additional information. This changing need for information for minerals is reflected in the Mineral Availability System (MAS) earlier introduced by the Bureau of Mines as the Bureau sought to improve its information capability regarding domestic resources. This Information Circular introduces a similar effort by the Bureau to improve information regarding demand for minerals. The SIC-based information system being implemented by the Bureau will enhance understanding of the role of minerals in the economy and improve the forcasting of the demand for minerals.

Evolving concerns about the preservation of environmental quality have raised questions not only about domestic mineral supplies, but also about the appropriate levels of use of minerals. Also the threat of nonprice restrictions such as mineral cartels that interfere with free trade in minerals may pose a threat to the economic welfare and national security of the United States. In order to understand and evaluate these issues, the data base regarding consumption of minerals in their numerous end uses should be significantly improved.

There is a need to know about material substitution in mineral-consuming industries. There is also a need to enhance our understanding about the intensity-of-use of materials in various sectors of the economy. Finally, there is an urgent need to improve the quantitative base to improve forecasting of the demand for minerals, so that the Government and industry can anticipate and provide for polices and programs to insure that such demand is appropriately satisfied.

The feasibility of the two-dimensional information system presented here and jointly developed by Penn State and the Bureau was first rigorously tested for one commodity, namely sulfur. The test was a success. Then, under research contracts from the Bureau, and with the active cooperation of Bureau personnel, Penn State expanded the case studies to include all information-critical minerals. These are defined to be those minerals for which end-use data are relatively vital, either because of dependence on foreign sources of supply or because the existing data base may be inadequate for resource policy decisions.

The Bureau is at present actively instituting the new end-use information system for nonfuel minerals. This new data system, when fully in place, is expected significantly to improve both understanding of the sectoral demand for minerals and forecasting of the demand for minerals.

THE NEW DATA SYSTEM

The new end-use data system is based on a two-dimensional approach using both technical product classes and end-use sectors. The new, two-dimensional system is consistent with the derived nature of the demand for minerals. The first dimension consists of a series of primary intermediate products of minerals that are designated as Technical Product Classes (TPC's). The second dimension consists of an extensive set of end uses defined by criteria established in the well-known Standard Industrial Classification (SIC) system of the Federal Government.

The end-use dimension is itself more accurately characterized as "commercial uses," as distinct from final consumption in the economy. In other words, the new data system measures the consumption of TPC's in such commercial uses as agriculture, construction, and manufacturing, but ignores service sectors.

The Standard Industrial Classification categorized establishments by their major economic activities, qualified somewhat by product specialization. The choice of SIC to define end-use sectors satisfies the primary objective of the data system; namely, to link the demand for minerals to economic activity and to other Government data sources.[5]

The Need for the New Data System

Primary minerals rarely find direct application in final consumption sectors, except in the case of industrial minerals. More often, minerals are used in the manufacture of intermediate products, the demand for which is derived from end-use markets. The demand for ferroalloy minerals, for example, is determined by the demands for steel, high-temperature alloys, and so on in end-use markets such as transportation.

Figure 1a shows schematically the linkage in the supply and demand for minerals. Figures 1b and 1c illustrate how the demand for goods in the end-use market influences the price and output of intermediate products. A shift in the demand for automobiles from Q_Z to Q'_Z (fig. 1c) calls forth an increase in the supply of steel from Q_X to Q'_X (fig. 1b). This, in turn, increases the quantities of iron ore and other ferroalloys demanded in the production of steel (from Q_M to Q'_M, not shown in fig. 1).

The above example illustrates that the market for primary minerals is the intermediate product market and not final consumption sectors. Firms in the mineral-producing industries perceive the demand response in the intermediate product markets and not demand in final consumption sectors.

The derived nature of the demand for minerals requires a two-dimensional information system. In terms of an

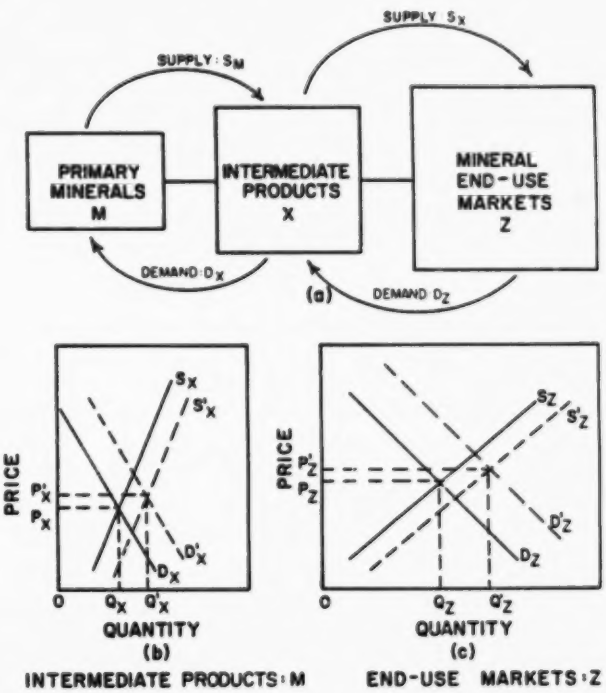

FIGURE 1. - Linkage in the supply and demand for minerals.

[5]Choice of SIC is justified in a later section entitled "Appropriateness of SIC To Define End Uses."

end-use data scheme for minerals, this means that the information should separate (1) the consumption of minerals in the production of intermediate products and (2) the consumption of these intermediate products in their end-use markets. Practical considerations in generating data, as well as cost effectiveness of the program, also justify this two-dimensional approach.

Usefulness of the New Data System

Effective management and rational policymaking require sufficient, reliable data. In the minerals sector, both the formulation of policy and the management of specific programs are to some degree hampered by insufficiently detailed data about the demand for minerals in end-use markets.

By explicitly linking the demand for minerals with economic sectors defined by SIC, policymakers and managers in various industries will then be in a position to interrelate the sensitivity of material demand with economic activity. The wealth of census and other information about economic activity can then be used more effectively in forecasting mineral demand.

In the few instances (for example, steel, aluminum, brass) where end-use data are now available, the usefulness of such data is limited because the "end-uses" classifications differ among them and often differ widely from those end-use sectors for which economic forecasts are available. The new data system alleviates this difficulty by providing a common classification system, and does so without sacrificing the wealth of available information. Translators[6] are used now to convert existing data into the data system. This insures better information without abridging the traditional role of trade associations and other agencies and provides these data at minimum additional cost and without breaching confidentiality.

By defining technical product classes that are common for various minerals and thus, wherever possible, standardizing information for different minerals, it will be possible to enhance intercommodity comparisons.

The new data system also recognizes that the information required for policy planning, for example, may differ in details from that required to forecast the demand for an individual mineral. An accommodation of these different levels of information is made possible by making effective use of the SIC two-digit, three-digit, and four-digit classifications. This hierarchical feature further enhances the usefulness of the information to various users.

Every effort has been made to present end-use data in a manner useful to industry in its market planning. In the new data system, this is achieved in several ways. First, where possible, existing trade association data systems are used as sources of input data in their entirety. This enhances the traditional value of such data by integrating them with the new SIC-based system. Second, many industry professionals were consulted in determining the scope of each TPC and of the end-use classes (appendix A). This consultation provided both quality control and understanding of the needs of private users of the new data. The new SIC-based system provides a basis for individual segments of the mineral industry to enhance their understanding as to how other materials compete or interact with their products in numerous markets.

[6]These are tables in which non-SIC market classifications are correlated with the coincident SIC end uses.

ELEMENTS OF THE END-USE DATA SYSTEM

The new end-use data system seeks to link the demand for minerals to economic activity. This linkage is achieved by means of a two-dimensional data system of TPC's and SIC's.

The first dimension defines the demand for minerals in the production of technical product classes (TPC's) such as carbon steel. The second dimension measures the consumption of these TPC's in SIC end-use sectors such as motor vehicles. SIC end-use sectors are so defined that intercommodity comparisons are possible at SIC two-digit levels, while simultaneously insuring a detailed classification that more accurately captures the demand for each TPC.

The Technical Product Class Dimension

Technical product classes (TPC's) are those groups of major intermediate products of a mineral for which separate end-use data are desirable, either because the particular TPC enhances understanding of the backward linkage to the demand for a primary mineral such as sulfur or because the TPC materially enhances the quality of end-use data by providing a category that is well understood by industry personnel.

Symbolic Definition of Technical Product Classes[7]

A mineral, M, may go either into the production of intermediate products, X_j, or directly into end uses, Z_i.

$$M = f(X_j, Z_i)$$

$$i = 1,\ldots,n;\ j = 1,\ldots,m \qquad (1)$$

Intermediate products, X_j, may be used to manufacture other intermediate products, Y_i, or may be used in end uses, Z_i.

$$X_j = f(Z_i, Y_i) \quad i = 1,\ldots,n \qquad (2)$$

If X_j's are considered as primary intermediate products, Y_i's may be regarded as secondary or tertiary intermediate products. An example of the primary intermediate product, X_j, is sulfuric acid, which is made from elemental sulfur or is recovered from other sulfur sources such as smelter gases. Sulfuric acid may then be consumed in fertilizers, Z_i, or may be used to manufacture a secondary intermediate product, such as aluminum sulfate, Y_i. Aluminum sulfate, in its turn, may be used in an end-use market, Z_i, such as paper, or may be used to produce tertiary intermediate products such as sodium aluminum sulfate (alum) and so on. Y_i's are, therefore, both secondary and tertiary intermediate products such as aluminum sulfate and alum.

Y_i's themselves go into commercial use, Z_i.

$$Y_i = f(Z_i) \qquad (3)$$

Demand for a primary mineral, M, in end-use markets, Z_i, then is

$$M = f({}_xM_{Z_i}, {}_yX_{J\,Z_i}) \qquad (4)$$

where ${}_xM_{Z_i}$ is the jth primary intermediate product of M that goes into end-use market Z_i, and ${}_yX_{J\,Z_i}$ is the kth intermediate product of X_j that goes into consumption in Z_i. Ideally, then, to understand the flow of minerals to end-use sectors, it is necessary not only to know the direct consumption of, say, sulfuric acid in water purification, but also to know the sequential data on the indirect consumption of sulfuric acid in the same end-use sector, via aluminum sulfate and alum.

[7]This section is important for persons who will be working with the canvass forms or who wish to understand the logic of incorporating TPC's into the new data system. Others may skip this section.

This is not practical to achieve when the steps necessary to obtain the data are considered. The sequential data gathering would require three separate canvasses: one canvass for the consumption of sulfuric acid in its end uses such as water purification and its intermediate products such as aluminum sulfate; a second canvass to repeat the same information for aluminum sulfate; and a third canvass for alum. A firm that produces all three products would be the recipient of three survey forms, an accumulation that might end its cooperation as a respondent. Furthermore, at each successive stage in the canvass, more and more firms have to be canvassed to complete the data. The immensity of such a sequential information gathering system and the costs associated with it can be estimated when the vast array of intermediate products made from sulfuric acid is recalled.

The organization of the chemical industry is such that a major firm's product line is seldom confined, as in the above case, to a simple product like sulfuric acid or its derivatives. The same firm may produce chemicals based on such materials as fluorine, chromium, and cobalt. For each firm in the industry, the cost of detailed data for a sequential information system is obvious.

Therefore, despite its attraction, a sequential information system to satisfy equation 4 is predestined to fail. At one stage or another, this sequential information gathering will have to be discontinued. The most practical step is to ignore the secondary and tertiary intermediate products, Y_i's, and confine the data base to the primary intermediate products, X_j's, of a mineral. Equation 4 is then modified to

$$M = f({}_{x_j}M_{Z_i}) \qquad (5)$$

This does not necessarily ignore the consumption of Y_i in Z_i. Producers of X_j are asked to estimate consumption of X_j, including X_j contained in Y_i. In the example of sulfuric acid, a producer of sulfuric acid is asked to report all shipments of sulfuric acid for use in water purification, including sulfuric acid used to manufacture water purification chemicals, aluminum sulfate, or alum.

In equation 5, X_j's are Technical Product Classes for a mineral, M. Z_i is a vector of end-use markets defined on the basis of Standard Industrial Classification. However, this is not such a a serious restriction as it first appears. The scheme of technical product classes is conceptually similar to defining a set of demand equations for a mineral.

In the case of sulfur, the demand for sulfur can be defined in terms of the demand for elemental sulfur and the demand for sulfuric acid. Thus, elemental sulfur and sulfuric acid are two TPC's (X_j) in equation 5 for sulfur. Demand for sulfur, D_S, then is

$$D_S = f(D_{S1}, D_{S2}) \qquad (6)$$

$$D_{S1} = g(Z_i) \quad i = 1,\ldots,n \qquad (7)$$

$$D_{S2} = g'(Z_i) \quad i = 1,\ldots,n \qquad (8)$$

In general, the demand for a mineral, M, in end-use sectors is given by a system of equations for technical product classes, X_j's.

$$M = f(X_1, X_2,\ldots X_m) \qquad (9)$$

$$X_j = g(Z_1, Z_2,\ldots Z_n) \qquad (10)$$

The formulation in equations 9 and 10 requires m canvasses to collect end-use data on these TPC's, and the solution sould involve a system of m+1 equations. Equation 10 does not show the direct consumption of M in final consumption sector Z_i. This is because, when relevant, the mineral itself is considered as one of the technical product classes for which end-use data are generated. For example, equation 5 is defined to include elemental sulfur, as well as sulfuric acid.

One intrinsic advantage of this formulation is that the data base is further simplified because there are X_j's

that might be common for several minerals, which further minimizes additional canvasses. For example, consider steel, a TPC, which is common for all ferroalloy minerals. The advantage is in the simplicity of the concept, and the cost effectiveness of gathering information. One set of information--namely, the end uses of steel--gives end-use information for several minerals such as manganese, chromium, and vanadium.

$$X_1 = g(Z_j) \qquad (11)$$

where X_1 is steel. Then, for each mineral contained in steel, M_i

$$M_i = f(a_i Z_j) \qquad (12)$$

where $a_i = \frac{X_1}{M_i}$, the contained mineral in a unit of X_1. Equation 12 assumes a direct proportional relationship between M contained in X_1 and M_i consumed in Z_j. This will be true only if X_1 is a homogeneous product. If X_1 is not a homogeneous product but a group of related products, then the coefficient, a_i, is an average for the group of products as a whole, $\bar{a}_i$, and equation 12 may only approximate the consumption of M_i in Z_j.

There may be some Z_j's in which an alloy with a higher unit content of M_i than the average $\bar{a}_i$ may be selectively demanded or vice versa. Therefore, although the average coefficient, $\bar{a}_i$, may be a good estimate of M_i in the production of X_1, it may not be a good estimate for purposes of equation 12, which is the objective of the end-use data collection system.

For example, say cobalt is the i^{th} mineral with X_1 being tool steel. The average coefficient, say, $\bar{a}_1$, which describes the ratio of cobalt contained in a unit of tool steel, is lower than the average contained cobalt, say, $\bar{a}_2$, in high-speed tool steel. However, the canvass on tool steel provides data only on the consumption of tool steel in end-use sectors, Z_j's. If one end-use sector, Z_k (say, aircraft) selectively demands high-speed tool steel in larger proportion than other tool steels one would be underestimating the demand for cobalt in the aircraft sector if the demand for cobalt in aircraft was estimated as $\bar{a}_1 \cdot Z_k$. Such an error traces to the use of the more general average coefficient instead of a more precise coefficient that is correctly weighted to reflect only the types of tool steel delivered to the aircraft industry.

The problem illustrated in the above example can be eliminated only if end uses for each separate cobalt-containing steel alloy are known. Such detailed information is unavailable for a variety of reasons. Hence, the best that can be expected is to use the methodology where TPC's are carefully designed to get the average coefficient, $\bar{a}_i$, as close as possible to the actual coefficient, a_i, so that $\bar{a}_i$ approximates the expected value of a_i.

In the illustrative case of cobalt, whereas $\bar{a}_i$ if measured as an average coefficient for <u>all</u> steel could create a serious flaw, $\bar{a}_1$ measured as an average for tool steel would be close to what can reasonably be expected from a commodity survey. Although using such average coefficients is a theoretical shortcoming in the two-dimensional end-use data scheme proposed in this study, no means were found during this study by which this problem could be entirely corrected. For example, it can be readily seen that high-speed tool steel is not a homogeneous product either, and the argument to separate high-speed tool steels from tool steel can soon be applied to each of the many high-speed tool steels manufactured, but this leads to an explosion of data.

The questions relevant to such a data explosion are can data be generated in such great detail, and are the marginal benefits so obtained commensurate with the cost of generating and processing such data. The answers to both questions are negative. Also, the greater the number of TPC's, the more narrowly

each TPC is defined and the more likely that the canvass will ask for information considered by firms as proprietary and lead to diminished cooperation.

Criteria for Selection of Technical Product Classes

Technical product classes for a mineral are those primary intermediate products that adequately capture the demand information for minerals in relation to end-use markets. A TPC performs a dual function in the information system by providing a backward linkage to demand for primary minerals, while satisfying the forward linkage to end-use sectors.

The selection of a TPC cannot be based upon a unique criterion. Rather, each TPC should be selected so that it represents the minimum number of primary intermediate products that together provide an information base adequate to quantify the flow of minerals in the economy. The selection of a TPC for a mineral is subjective, and the TPC's for a particular mineral are not fixed over time. Technical product classes may change as technology changes. The criteria for selection of technical product classes are best illustrated with an example. The case of fluorine is discussed below.

Figure 2 shows the three TPC's selected for fluorine--fluorspar, hydrofluoric acid (HF), and fluorsilicic acid--drawn as diamond-shaped boxes. Rectangular boxes in figure 2 represent all major intermediate products derived from hydrofluoric acid or fluosilicic acid. Note that these intermediate products themselves may go into mineral

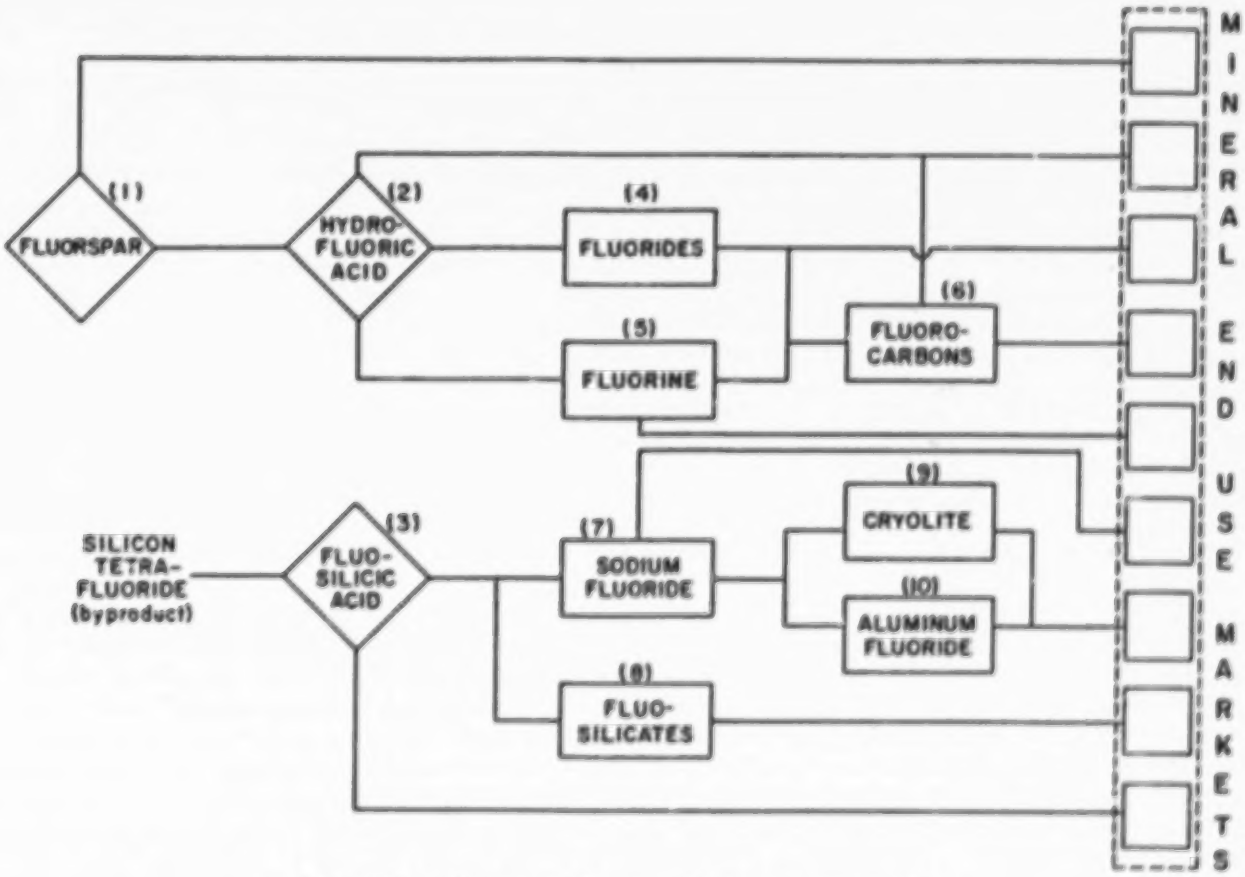

FIGURE 2. - Schematic diagram of fluorine compounds.

end-use markets or may go into the production of other intermediate compounds. For example, fluorides (manufactured from HF) may go into mineral end-use markets or may go into the production of other intermediate compounds. For example, fluorides (manufactured from HF) may go into final consumption (for example, water fluoridation, glass, and ceramics) or may be used as fluorinating agents that produce additional intermediate products such as organic compounds of fluorine (fluorocarbons).

The numbered boxes in figure 2 indicate that in one possible, hypothetical, detailed scheme, there are 10 possible technical product classes for fluorine that would require an equal number of questionnaires to elicit data from firms in the industry. Since more than 75 percent of hydrofluoric acid is consumed at captive plants, it also implies that a firm that manufactures HF would be the recipient of questionnaires 2, 4, 5, and 6. Similarly, a producer of byproduct fluosilicic acid could receive up to five questionnaires (3, 5, 8, 9, and 10). This complexity obviously would be unacceptable to industry.

One of the end-use markets for fluorine is in glass and ceramics, shown in figure 3. This sector uses various fluorine compounds for a variety of applications, such as providing transparency (fluorspar, cryolite), etching and polishing (hydrofluoric acid),

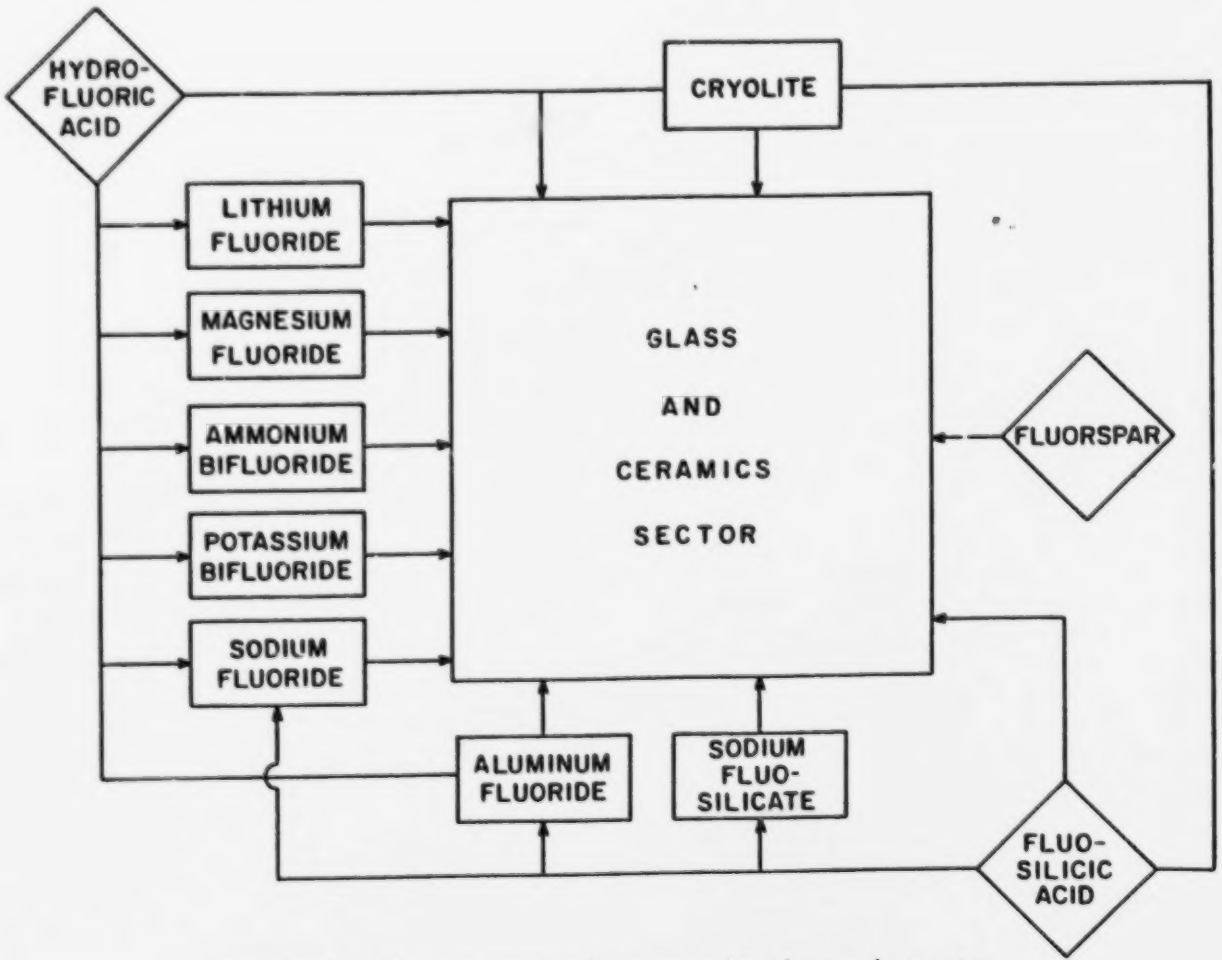

FIGURE 3. - Fluorine compounds consumed in glass and ceramics.

enamels and glazes (lithium fluoride), frosting (potassium bifluoride), and imparting opalescence (sodium fluosilicate). If the analyst knew only consumption of all fluorine in glass and ceramics, it might not be sufficient because this demand is satisfied using three different sources (TPC's) of fluorine units. First, there is the consumption of fluorspar. Second, there is consumption as hydrofluoric acid and its compounds produced from acid-grade fluorspar, and third, there are products obtained from fluosilicic acid, which is a new source of supply of fluorine and is a byproduct of phosphate processing. There is also merit in knowing consumption of hydrofluoric acid and products made from it versus consumption of fluosilicic acid and its compounds, because such a data base would indicate the substitution of fluorine compounds from two distinct and separate primary sources of fluorine.

The classification in figure 3 of fluorine into three TPC's (see diamond-shaped boxes for fluorspar, hydrofluoric acid, and fluosilicic acid) is amply justified. But to classify as separate TPC's each of the eight compounds outlined in figure 3 as rectangles (cryolite, sodium fluoride, etc.) would be unwarranted because such a data explosion would not be justified by a corresponding increase in usefulness of the data collected.

What should be expected from an end-use data base is a report of the consumption of fluorine in end uses such as "Glass and Ceramics," aggregated in a way that would permit estimation of the supply requirements of fluorine given a forecasted level of activity in the glass and ceramics sector. This linkage to supply is amply satisfied if data can be collected for consumption of ceramic-grade fluorspar, acid-grade fluorspar (hydrofluoric acid), and fluosilicic acid, the diamond-shaped boxes of figure 3. The information base would not be strenghthened significantly if the consumption was determined separately for each of the compounds derived from either or both hydrofluoric acid and fluosilicic acid. Efficiency and cost dictate that the number of TPC's be limited in this case to three, the minimum required to satisfy the data objective.

In summary, the approach by the Bureau is to collect end-use data for a limited number of TPC's for each mineral. These TPC's are major intermediate products or groups of closely related intermediate products. The objective in selecting TPC's for a mineral is to limit them to the minimum number required to quantify the final consumption characteristics of a mineral subject to the availability of data. Appendix B provides a list of the TPC's studied and a guide to the project report in which the sources for end-use data for each commodity are discussed in detail.

Additional Criteria for Classifying Technical Product Classes

An important consideration in defining a TPC for a mineral is that it should be limited either to one product or to a group of closely related products. In this manner consumption of mineral in that TPC can be determined with a degree of confidence.

For a mineral such as iron ore, one TPC, namely steel, would be amply sufficient. However, steel is relevant not only to iron ore but also to all other ferroalloy minerals. Therefore, end-use data on steel will be provided by the Bureau in such a way as to give best results not only for iron ore but also for other ferroalloy minerals. In the Bureau of Mines' new end-use information system, steel is separated into six TPC's: Carbon steel, alloy steel, tool steel, stainless steel, heat-resistant steel, and high-strength, low-alloy (HSLA) steel.

Demand for chromium, for example, is more closely related to the demand for stainless steel than to any other type of steel. Similarly, for molybdenum it is the consumption of tool steel that is most important, and for cobalt it is tool steel and perhaps specialty steels

(high-temperature alloys). Therefore, even though at first steel is thought to be a single TPC for iron ore, once it is decided to generate end-use data on steel, it is wise to consider the several steel types as intermediate products common for several alloying minerals.

The basis for the definition and selection of a particular TPC is as follows: (1) A link backward to supply, (2) a link with historical data, (3) a classification common to several minerals, and (4) a minimum number of TPC's. Therefore, the task of selecting the appropriate number of TPC's for a primary mineral is one of finding the set of intermediate products that best satisfies all four criteria.

For steel, the first two of these criteria are met by making maximum use of the existing data base of the Bureau. When the Bureau collects data on intermediate products it was determined (1) how far these satisfied other desirable criteria and (2) whether these products could be regrouped in a manner by which historical continuity (with the preexisting data scheme) was preserved while minimizing the number of TPC's.

Table 1 compares the intermediate products for which the Bureau at present collects data with the seven proposed TPC's for the cobalt end uses. The seven letters (a to g) indicate the grouping of the Bureau's present list of intermediate products within the seven TPC's. For example, the Bureau's category Tool Steel (d) would be retained as an independent TPC, while all the other steel categories in the present Bureau classification would be grouped together under one TPC, Other Steels (e). This concept preserves the link between the new end-use data collection scheme and the existing data base of the Bureau.

Column 1 of table 1 lists seven TPC's for cobalt (a to g). This may seem to be a large number of TPC's for one mineral. However, for a mineral such as cobalt that finds diverse specialized applications, it appears unavoidable. One of the basic criteria for defining a TPC is that it will be a group of closely related products, so that reasonable assumptions can be made about contained mineral (in this case cobalt) in that TPC.

The six metallic product classes for cobalt are common to a host of ferroalloy minerals, such as nickel, chromium, columbium, tantalum, and tungsten (table 2). In other words, in the new system a TPC such as high-temperature alloys is not exclusive to cobalt. It is also a TPC for the five other ferroalloys shown in table 2. Therefore, across the spectrum of ferroalloy minerals, the number of TPC's can still be kept to a manageable level. Penn State has suggested a total of 42 TPC's to collect end-use data on 23 minerals.

The test for an additional TPC is not whether one more TPC is desirable, but whether the objective of the data collection system can be met without it.

TABLE 1. - Comparison of Bureau of Mines intermediate product classes for cobalt with proposed technical product classes

Proposed technical product classes (TPC's)	Location code	Approximate consumption in 1974[1] (percent of total)	Present USBM classification	Location of data with proposed TPC's
Metallic:			Superalloys.....	a
High-temperature alloys.....	a	21.7	Alloys (excludes alloy steels and superalloys):	
Magnetic alloys.....	b	18.3	Magnetic alloys.....	b
Carbides and hardfacing alloys.	c	16.0	Welding and alloy hardfacing rods and materials.....	c
Tool steels.....	d	3.7	Cutting and wear-resistant material....	c
Other steels.....	e	1.6	Nonferrous alloys.....	f
Cobalt--other metals and alloys	f	7.5	Other alloys.....	f
Nonmetallic: Cobalt compounds...	g	31.3	Mill products made from metal powder.....	f
			Steel:	
			Carbon.....	e
			Stainless and heat resisting.....	e
			Alloy (excludes stainless and tools steel).	e
			Tool.....	d
			Cast irons.....	f
			Chemical and ceramic uses: Pigments.....	g
			Catalysts:	
			Ground coat frit.....	g
			Glass decolorizer.....	g
			Other.....	g
			Miscellaneous and unspecified.....	g
			Salts and driers: Lacquer, varnishes, paints.	g

[1]Source: Metal statistics, 1976.

TABLE 2. - TPC's common for ferroalloy group of minerals[1]

Mineral commodities	Steel (e)						(a) High-temperature alloys	(b) Magnetic alloys	(c) Carbides and hard-facing alloys
	Carbon	High strength, low alloy	(d) Tool	Alloy	Stainless	Heat resisting			
Chromium...		X	X	X	X	X	X	X	X
Cobalt[2]....			X	X	X	X	X	X	X
Columbium..		X	X	X	X	X	X	X	X
Nickel.....		X	X	X	X	X	X	X	X
Tantalum...			X	X	X	X	X	X	X
Tungsten...			X				X	X	X

[1]Excludes manganese, molybdenum, tellurium, vanadium, etc., which were not part of the present study.

[2]Cobalt uses are coded the same way as in table 1. For example (d) means the commodity currently is found in the tool steel TPC.

End Uses--Description of the Dimension

The end-use sectors of a mineral commodity provide the necessary second dimension to a fully specified mineral information system, the first dimension being the technical product classes (TPC's) discussed above. To define end uses the Bureau has chosen the SIC system.

End use--for purposes of the new data system--is best defined as that use at which a TPC is delivered in the U.S. economy to a final commercial use, such as manufacturing, agriculture, or construction. SIC-based commercial uses are defined for each TPC such that the TPC is used in a consumer good (steel in automobiles), or becomes untraceable further (sulfuric acid in the making of paper).

A mineral commodity may pass through several stages of manufacturing or fabrication before its final commercial application. In such cases, it may not be clear which point of consumption represents final commercial use. This problem is compensated for by selecting the appropriate number of mutually exclusive TPC's for a mineral and collecting end-use data for each TPC.

Data availability may further restrict the ability to obtain data in terms of commercial uses. Therefore, intermediate product uses such as "paints" may have to be retained as end uses, although conceptually more appropriate commercial uses could be conceived (for example, automobiles, construction). Such exceptions are infrequent and are made only when respondents (during preparation of the questionnaire) indicated that they could not provide greater detail.

Distinction Between Commercial Uses and Intermediate Product Markets

Firms generally wish to have information about specific product markets in which their own products are used. These we have defined as tertiary intermediate products. This desire of producers to identify product markets often creates a conflict with the economic analyst who wishes to select commercial uses relevant to measuring overall demand for minerals.

Fluorine provides a good example to illustrate the disadvantage of defining intermediate products as "end uses" of minerals. Earlier, fluorine was used as an illustration to discriminate between primary and tertiary intermediate products in making proper choice of TPC's. The same commodity is used as an example in this section to discriminate between tertiary intermediate products and

commercial uses for proper determination of end uses that measure demand on a national scale.

Table 3 lists some of the major fluorine compounds and the commercial uses in which these compounds are consumed. A product definition of the markets for fluorine is identical with column 3 of table 3, "Fluorine compounds." Use of such an end-use definition would provide information on the consumption of fluorspar (and presumably hydrofluoric and fluosilicic acid) in the production of various compounds listed, such as aluminum fluoride or various fluosilicates. But, it can be readily seen that (1) several fluorine compounds are demanded in the same end-use market, and (2) the same compound (for example, aluminum fluoride) is demanded in different end-use markets. Therefore, it can be recognized that a product-based definition is clearly inappropriate to describe the end-use markets for fluorine.

Column 2 of table 3, "End-use titles," on the other hand lists end-use markets for fluorine. Information based on these end-use markets will provide a basis for understanding the demand for all fluorine products in a well-defined manufacturing activity.

Perspectives on the Market Versus Product Definition

The principal reason for the persistence of the conflict between market definitions and product definitions is the underlying conflict between the need for product data by firms in the industry, and the market data an economic analyst needs to understand demand for minerals in the economy. Both are useful, but the two are not always coincident.

In the methodology developed for this study and described in the earlier section, "Symbolic Definition of Technical Product Classes," the "secondary" and "tertiary" intermediate products are ignored (Y_I in equation 2). It is assumed that information about the consumption of "primary" intermediate products in end-use markets (Z_I) is sufficient to satisfy the general objective of an information system that traces the flow of materials in the economy. Both practical considerations in collecting and processing the information and the cost-effectiveness of the program justify the proposed methodology.

However, the firms that produce the primary mineral products (X_J) often sell them in the market for secondary and tertiary intermediate products (Y_I). Because the primary producers (X_J) sell to the intermediate market (Y_I), they may not be concerned with the final end use; that is, they may not know their customers' markets (Z_I). When there are several producers of primary products, the concern of each of them is to increase its share in the market for intermediate products. A producer of fluosilicic acid, for example, will be concerned primarily about a market for fluosilicic acid in the production of synthetic cryolite (Y_I). Whether the customer uses its production of synthetic cryolite in producing aluminum (Z_I), or sells it to ceramics manufacturers (A_I), is usually of minor importance to the acid producer.

Thus the level of information desired by firms in the industry may differ considerably from the objective of the Government in initiating an end-use survey. Having recognized this difference, the relevant questions then are

1. Whether the Bureau of Mines can generate end-use data in a step-by-step sequential manner, tracing consumption of a mineral through the several intermediate uses to a final commercial use, and

2. If such a sequential canvass is not possible, whether the global data the Bureau needs will help the industry sufficiently in its business decisions to provide the necessary incentive for industry to participate in an end-use data scheme.

TABLE 3. - End-use applications of fluorine compounds

SIC code	End-use title	Fluorine compounds
13	Oil and gas extraction.....	Chlorine trifluoride, ammonium bifluoride, hydrofluoric acid, silicon tetrafluoride.
20	Food and kindred products.....	Ammonium bifluoride, fluosilicic acid, copper fluosilicates, sodium fluoride, perfluorosyclobutane.
22	Textiles.....	Boron trifluoride, fluoborates, perchlorofluoro acetones.
	Chemicals, and allied products:	
281	Industrial inorganic chemicals.....	Fluorspar, magnesium fluoride, potassium bifluoride, hydrofluoric acid, fluosilicic acid.
282	Plastics, materials, and synthetic resins, rubber, and man-made fibres.	Hydrofluoric acid, aliphatic chlorofluoro hydrocarbons, poly (tetrafluorethylene) (PTFE).
283	Drugs.....	Perchloryl fluoride, silver fluosilicate, perchlorofluoro acetones, fluorinated aromatic compounds.
284	Soaps, cleaners, and toilet goods.....	Fluosilicates of calcium, magnesium, and zinc; sodium bifluoride; sodium monofluoro phosphates; stannous fluoride.
286	Industrial organic chemicals.....	Fluoborates, hydrofluoric acid, potassium fluoride, etc.
2801	Other chemicals.....	Aluminum fluoride, boron trifluoride, hydrofluoric acid, etc.
291	Hydrofluoric acid, lithium fluoride	
	Stone, clay, and glass products:	
321	Flat glass.....	Aluminum fluoride, cryolite, ammonium bifluoride, fluorspar, hydrofluoric acid, lead fluoride, lithium fluoride, etc.
324	Cement.....	Fluorspar, silicon tetrafluoride, zinc fluosilicate.
325	Structural clay products.....	Aluminum fluoride, lithium fluoride.
326	Pottery and related products.....	Aluminum fluoride, cryolite, hydrofluoric acid, lithium fluoride, sodium fluoride, magnesium fluoride.
329	Abrasives and miscellaneous nonmetallic products.	Cryolite, fluoborates, fluorspar, fluorozirconates.
	Primary metal industries:	
331	Steel mills.....	Fluorspar, hydrofluoric acid.
332	Iron and steel foundries.....	Cryolite, fluorspar, hydrofluoric acid, sodium fluoride.
3334	Primary aluminum.....	Aluminum fluoride, cryolite, fluoborates, hydrofluoric acid, fluosilicic acid.
3301	Other primary metal industries.....	Aluminum fluoride, fluoborates, hydrofluoric acid, fluorozirconates, PTFE, lithium fluoride, sodium fluoride, etc.
3471	Plating and polishing.....	Fluoboric acid, fluoborates, fluosilicic acid, sodium bifluoride, zinc tetrafluorosilicate.
358	Refrigeration and service machinery.....	Sulfur hexafluoride, carbon tetrafluoride, carbon tetrafluoride, CCl_2F_2, CCl_3F, $CBrF_3$, etc.
	Electrical and electronic equipment:	
361	Electric distributing equipment.....	Sulfur hexafluoride, perchloryl fluoride, perfluorocyclobutane.
363	Household appliances.....	PTFE, carbon tetrafluoride, $CHClF_2$.
3601	Other electrical and electronic equipment.	Fluoborates, PTFE, Poly (chlorotrifluorethylene) (PCTFE).
376	Guided missiles and space vehicles, and parts.	Nitrogen trifluoride, perchloryl fluoride, sulfur hexafluoride, fluoborates, PTFE, carbon tetrafluoride, $CBrF_2$.
38	Instruments and related products.....	Lithium fluoride, magnesium fluoride, fluorspar.
	Water treatment.....	Fluorsilicic acid, fluosilicates, cryolite.

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The answer to the first question is clearly in the negative. The costs of collecting and collating data in such detail would be excessive. Firms that perhaps justifiably complain about their own escalating costs in the "unproductive" exercise of providing a multiplicity of data to various Government agencies also will not be indifferent to their share of the costs. Also, the more detail in which data are collected, the more it will encroach on proprietary information of various firms in the industry, a situation that neither the industry nor the Government considers advisable.

Therefore, an end-use data collection system sponsored by a Government agency must, of practical necessity, be such as to insure (1) a least-cost data base adequate for policy decisions and (2) the least expenditure of reporting time by industries as a whole. The question then is whether such a data base will give the industries a return commensurate with their voluntary participation in collecting and reporting such data. Reporting efficiency is a significant consideration in designing mineral end-use surveys.

It is important here to recall that the demand for minerals is derived demand. Therefore, for example, if the Government is in a position to estimate what impacts its policy regarding the construction market may have on the demand for mineral commodities, this will provide several benefits to mineral producers. The direct benefit is in having such information to guide business decisions. An indirect benefit will accrue if such information will help improve Government decisions concerning its policies toward that sector or industry. For another, the data base itself will be valuable for market planning by firms. It is possible that a few large firms may already have such information and hence may apparently not be benefited by it. But even in such instances, private estimates are no substitute for industrywide data. The existence of trade associations and their role in collecting statistics attest to the value of industry data. Similarly, trade associations themselves will benefit from SIC-based end-use information because it provides a comparable data base between competing industries and hence better interindustry data for association members.

The new end-use data base described here will not substitute for a firm's own market research needs. A firm's "need to know" regarding the markets for its products cannot be met fully by a service from the Government. What the Bureau is providing with the end-use data is a better information base for intraindustry and interindustry comparisons within which individual firms can pursue their own marketing interests.

APPROPRIATENESS OF SIC TO DEFINE END USES

Standard Industrial Classification (SIC) is the most widely understood and widely used "classification of establishments" to categorize the U.S. industrial structure. Therefore, the Bureau's objective of linking demand information for minerals with domestic economic activity is best achieved by defining end uses on the basis of SIC. However, the appropriateness of SIC to define end uses of minerals is not without its problems.

There are questions about whether SIC "establishments" are appropriate to define end-use categories. There are also questions about the appropriate detail of SIC groupings, and there are doubts about the ability of the various industries to report end-use data on the basis of SIC.

The first two questions are not entirely independent of each other. However, in order to separate the methodological problem from the choice of detail, these two questions are discussed separately.

SIC classifies establishments based upon criteria such that establishments in

the industry (1) consist largely of those goods and services defining an industry, and (2) account for the bulk of the specified goods and services provided by establishments in that industry. The underlined words emphasize the major criticism of using SIC to define end-use markets for minerals in terms of goods produced.

It was a conclusion of studies at Penn State that such definitional problems are not unique to SIC and would exist in any classification scheme. This can be readily illustrated. Those firms that participated in the present study agreed that "construction" is an appropriate end-use category for mineral commodities. But not all industries that serve construction markets would agree to have one end-use category, "construction." It was generally believed that "building construction" should be treated as a separate subcategory. Those industries that serve a specific market in building construction, such as "builders' hardware," wished to have that specific market identified as a second-order subcategory, and even then there was no agreement on how the category "builders' hardware" should be defined. There were those who insisted that furniture hardware is part of the building construction market and should therefore be classified as "builders' hardware"; others disagreed.

The above example illustrates that even in the case of a universally accepted category such as "construction," there was no agreement as to how many subcategories are adequate, much less as to the proper definition of the subcategories. In other words, definitional problems are inherent in any classification scheme, and using an SIC-based classification of "construction" is no worse than using any alternative scheme.

The second challenge to use of SIC regarded choice of the appropriate level of the SIC system, which is based on a hierarchy of several levels of classification. SIC major groups are two-digit. These are further classified into three-digit groups that may in turn be classified into four-digit industries.[8] For purposes of collecting statistics, the Department of Commerce has further elaborated upon SIC to define five-digit product classes and seven-digit products in order to specify products manufactured in SIC establishments.

It is necessary to distinguish the five- and seven-digit product classification used by the Deparment of Commerce from the Standard Industrial Classification of economic establishments that goes no further than SIC four-digit industries. The five- and seven-digit product classification is entirely inappropriate for classifying end uses of minerals. The new data system of the Bureau is confined to the two- , three- , and four-digit industries defined in the Standard Industrial Classification.

The new data system of the Bureau makes use of the hierarchical structure of the SIC. Intercommodity comparison is achieved at the SIC two-digit level. Demand information for each technical product class is obtained for all relevant SIC two-digit major groups and three-digit groups. In those instances where a particular four-digit industry represents a major end-use market, that industry is classified as a separate end use.

The third and last question regarding the appropriateness of the use of SIC to classify end uses of minerals relates to the ability of firms in the industry to report data. This ability differs from one segment of the mineral industry to another and among different firms. Therefore, for each TPC, a separate

[8]SIC 3361 provides an example of the concept of the four-digit hierarchy. The first two digits, 33, provide the code of a major group, "Primary Metal Industries". The third digit, 6, shows it is the Nonferrous Foundry group within the major group, and the fourth digit in 3361 shows it precisely as the Aluminum Foundry portion of the Nonferrous Foundry group.

determination was made in consultation with industry representatives to assure that firms in the industry are indeed capable of reporting the required end-use information. The reporting burden on firms is also further reduced considerably by making use of translators to convert into the SIC end-use format data that are already available from existing reports from the Government or trade associations.

Service Sectors Excluded

For purposes of the new data system, the SIC end-use classification is limited to commercial uses in manufacturing. Service sectors are excluded. This is done because

1. In the overwhelming majority of cases, manufacturing is the appropriate end-use sector for minerals.

2. Consumption in manufactured goods, such as consumer durables, can be considered as the final market because over the life of a good, it is not available for reuse.

3. Recycling of manufactured goods is a source of secondary supply for several minerals commodities. If the manufactured goods generate secondary supply, that fact provides a good test that the buyers of those goods should be considered as end users.

4. Even in those instances where a service sector may appear to be highly relevant as an end-use category (for example, the electrical utility market for copper), it is possible to specify an appropriate SIC manufacturing sector without any loss of information. Therefore, for purposes of end-use data, it is unimportant whether a manufacturing sector or a service sector is specified, except for consistency in practice.

5. More often, in place of one well-defined manufacturing sector, it would be necessary to specify several service sectors that are not mutually exclusive, thereby increasing definitional problems, as well as creating the potential for inconsistent reporting of data.

6. The intensity-of-use of the materials and substitution between materials are relevant only in terms of manufacturing sectors. An information system that identifies these phenomena is crucial to determining the nature of the demand for minerals and in assisting in forecasting demand for minerals, a major objective of the new data system.

Two- and Three-Digit SIC Classes Preferred

One objective of the new end-use reports is to improve the data base for forecasting demand for primary minerals, given activity levels in end-use markets. This implies that the end uses specified for mineral commodities should be those (1) that are important for estimation of demand and (2) for which economic forecasts are readily available. Both of these goals are best attained through use of a limited number of mutually exclusive end uses. It would also be easier for the firms responding to Bureau canvasses if the end uses listed on a survey form are held to the minimum number necessary to capture the significant consumption patterns for that commodity.

The basic requirements of the end-use information system are best served if the proposed SIC end uses are limited to two-digit and three-digit groups, with exceptions provided when necessary. This can be done in an SIC end-use classification because SIC is structured so that four-digit industries are grouped within three-digit groups, which in turn are grouped within a two-digit major group. Hence, if the analyst specifies a three-digit group instead of a four-digit industry, or a two-digit major group instead of a three-digit group, there is no loss in distinction among groupings despite a loss of detail in a particular group. Each specified end use should be sufficiently descriptive of a particular major end use of the mineral commodity. In general, as proved in several case studies, this distinction is achieved at

the SIC three-digit level. For cases where total consumption at any two-digit level is a minor but reportable part of the total consumption, distinction may be attained at the two-digit level.

As a general rule, limiting end-use classification to SIC two- or three-digit groups also helps to minimize some of the common problems associated with the end-use classification itself or in reporting data. It is certainly easier for a mineral producer to report his shipments to the two-digit group, SIC 25, Furniture and Fixtures, than, for example, if he were asked to specify end uses in three-digit groups, SIC 251, Household Furniture, and SIC 255, Office Furniture. By the same token, it would be many times more difficult if the respondents were asked to specify four-digit industries such as Metal Household Furniture (SIC 2514) and Mattress and Bedsprings (SIC 2515).

Even if a mineral producer has the ability to report shipments to such four-digit industries as SIC 2514 or SIC 2515, that does not imply that data reported at such levels would be more accurate that data reported only at the corresponding three-digit level. In fact, the converse may be true. At the more aggregated levels (smaller SIC numbers), customer identification becomes more clear and hence may result in more consistent reporting among respondents. One advantage of SIC is its hierarchical classification system which permits different firms with differing abilities to report data at the level most convenient to each, without losing comparability for data among different reporting firms.

By collecting data at higher levels of aggregation (SIC two- and three-digit groups), there is a reduction in data incompatibility among reporting firms. A producer may combine into SIC 3519 its shipments to Marine Engines (SIC 3519) and also to Ship Building and Marine Equipment (SIC 373). This error could then invalidate the data for SIC 373 received from this respondent. However, if SIC 37, Transportation Equipment, is considered, the error at the two-digit level caused by the producer's reporting procedure would be negligible, because shipments to marine engines then becomes such a small percentage of total shipments to all transportation equipment. In general, data tend to become more reliable at higher levels of aggregation (smaller SIC numbers).

As a final justification of higher aggregation, we note that some firms have indicated that in certain cases if data are reported at the four-digit level, it may amount to divulging their customers' identity, and hence, they wish to report data only at three- or two-digit levels. Therefore, by specifying two- or three-digit groups, problems of confidentiality also tend to be minimized.

SURVEY FORMS AND METHODS

Identification of the TPC dimension and the end-use dimension is only the necessary first step in developing statistics about consumption of minerals in commercial uses. It is next necessary to integrate these principles into a convenient format to gather information.

In the new data system, this is achieved by preparing translators to convert existing data into SIC format and by designing new survey forms for those TPC's for which a new canvassing format is required.

Design of the Survey Form

Before a canvass survey form is designed for a given mineral, it is essential to determine (1) the TPC's for the mineral, (2) whether there is a need for a separate canvass survey form for each of the TPC's or if several TPC's can be accomodated as separate columns combined into one canvass survey form, and (3) a simple form design to capture the essential information and to facilitate uniform reporting by all firms that are canvassed.

The canvass survey form may be designed for a mineral or for each TPC for that mineral. The general principle adopted in the end-use surveys is to have a separate questionnaire for each TPC. This follows essentially from the definition of TPC's and the care exercised in defining TPC's.

Sometimes, however, the cost of the survey is minimized by designing one combined questionnaire for several TPC's. This occurs when (1) the end-use sectors of two or more potential TPC's are more or less common to both, (2) the TPC's are produced by firms in the same industry, or (3) both of these factors are combined. An example of a combined form with three TPC's is shown in table 4, a questionnaire for zinc compounds. Here an end-use survey for three zinc compounds--zinc oxide (the most important zinc compound), other zinc compounds, and zinc dust[9]--are all combined into one canvass survey form.

Table 4 also illustrates the basic design of an SIC-based questionnaire to canvass firms in a particular industry. The first two columns describe the SIC classifications relevant for this TPC. Data on shipments are entered in the last three columns.

[9]Zinc dust either substitutes for zinc compounds in some end-use sectors, such as paints, or is the starting point for the continued production of other zinc compounds.

The first stage in the design of this questionnaire was the process of identifying the several secondary and tertiary intermediate products of the TPC, which led to a table such as table 5. This second table serves two purposes. First, it insures that all the relevant end-use sectors are considered for inclusion in the canvass survey form. Second, it gives a preliminary idea as to whether it is sufficient to ask for data for all zinc compounds together, or whether a distinction is required among the more important products. It can be seen from table 5 that in several end-use sectors both zinc oxide and other zinc compounds derived from zinc oxide are used. Thus, this type of table allows the analyst to draw a first conclusion that data on zinc oxide should be collected separately from data on other zinc compounds.

The second step in the design of a questionnaire is to correlate the mineral's end uses such as are shown for zinc in table 5 with SIC groups or industries. Whether a three-digit group or a four-digit industry is selected will depend upon (1) the percent of total consumption accounted for by that SIC category and (2) the extent of overlap in consumption among various four-digit industries in the three-digit group. The general rule that has been developed, with the help of several case studies, is that a four-digit industry will be specified only in exceptional cases when required to give clarity to the data or when the consumption in the specified industry is highly significant.

TABLE 4. - Proposed canvass survey form for zinc compounds

SIC code	End-use industries	Shipments, pounds of contained zinc: Zinc dust	Zinc oxide	Other zinc compounds
01[1]	AGRICULTURE			
22	TEXTILES			
24	LUMBER AND WOOD PRODUCTS			
26	PAPER AND ALLIED PRODUCTS			
28	CHEMICAL AND ALLIED PRODUCTS			
2816	Inorganic pigments			
2822	Synthetic Rubber (vulcanizable elastomers)			
2823	Synthetic manmade fibers, rayon			
284	Soap, cleaners, and toilet goods			
285	Paints, varnishes, and allied products			
2899	Soldering and welding flux			
2801[2]	Other chemicals			
28	CHEMICALS AND ALLIED PRODUCTS Subtotal			
2992	LUBRICATING OILS AND GREASES			
30	RUBBER, NATURAL			
32	CERAMICS AND GLASS PRODUCTS			
325	Floor tile and other structural clay products			
326	Pottery and related products			
3201[2]	Other ceramics and glass products			
32	CERAMICS AND GLASS PRODUCTS Subtotal			
347	ELECTROPLATING, PLATING AND COATING			
3679	FERRITES			
	OTHER IDENTIFIED END USES (Specify)			
	UNIDENTIFIED END USES			
	EXPORTS			
	TOTAL			

[1]Corresponds to Division A, "Agriculture, Forestry, and Fishing"; 01 is used to avoid alphanumeric coding.

[2]This is not an SIC code. Subscript 01 is added to a 2-digit code to report all other shipments to that 2-digit category, except those 3- and/or 4-digit categories specified.

TABLE 5. - End uses of zinc compounds

End-use description	Zinc oxide	Zinc chloride	Zinc sulfate	Other zinc compounds
Synthetic rubber	X	X		X
Natural rubber	X			X
Rayon	X		X	
Textiles	X	X	X	X
Wood preservative		X	X	X
Cosmetics		X		X
Fungicides	X	X		X
Paper		X		X
Lubricants		X		X
Dry batteries		X		
Electroplating				X
Galvanizing		X	X	X
Ceramics	X			X
Phosphors	X			X
Laundry soap				X
Agriculture			X	
Dyes		X		
Cement plaster				X
Pharmaceuticals				X
Paints	X		X	X

Table 6 shows an end-use questionnaire for hot-dip galvanized steel, one of the more lengthy forms. A basic feature of the standardized design of this questionnaire is the use of the tiered structure of SIC that is intended to increase the accuracy of data reported at higher levels of aggregation, such as the SIC two-digit group 34. This tiered structure satisfies the objective to collect data as accurately as possible for all significant consumption (that is, greater than or equal to 1 percent of total) within SIC two-digit major groups. In the case of agriculture, SIC end use is specified at the two-digit level. In other instances, a three-digit group (341) or a four-digit industry (3446) is specified. In such cases where three-digit groups or four-digit industries are specified, the questionnaire has the respondent calculate a group subtotal for each relevant two-digit major group.

As a general rule, all survey forms are designed with separate categories for each SIC end use that constitutes more than 1 percent of total shipments. The arbitrary cutoff point of 1 percent has been established below which an SIC end-use questionnaire entry line will not be assigned. This cutoff serves as a significance test that, while it limits entries on a questionnaire to a manageable number, also provides data for all significant uses.

TABLE 6. - Questionnaire showing shipments of hot-dip galvanized steel by end-use industries

SIC code	End-use industries	Shipments, net tons
01[1]	AGRICULTURE	
	CONSTRUCTION	
152	Residential building construction	
154	Nonresidential building construction	
16	Highway and other heavy construction	
	CONSTRUCTION Subtotal	
25	FURNITURE AND FIXTURES	
2514	Metal household furniture	
2501[2]	Other metal furniture and fixtures	
25	FURNITURE AND FIXTURES Subtotal	
34	FABRICATED METAL PRODUCTS	
341	Metal cans and shipping containers	
3446	Architectural metal work	
3462	Iron and steel forgings	
3496	Miscellaneous fabricated wire products	
3401[2]	Other fabricated metal products	
34	FABRICATED METAL PRODUCTS Subtotal	
35	MACHINERY, EXCEPT ELECTRICAL	
352	Farm and garden machinery	
353	Construction, mining, and related machinery	
3551	Food products machinery	
3501[2]	Other machinery, except electrical	
35	MACHINERY, EXCEPT ELECTRICAL Subtotal	
36	ELECTRIC AND ELECTRONIC EQUIPMENT	
361	Electric distributing equipment	
363	Household appliances	
3644	Non-current-carrying wiring devices	
3601[2]	Other electric and electronic equipment	
36	ELECTRIC AND ELECTRONIC EQUIPMENT Subtotal	
37	TRANSPORTATION	
3714	Motor vehicle parts and accessories	
3701[2]	Other transportation	
37	TRANSPORTATION Subtotal	
39	MISCELLANEOUS MANUFACTURING	
394	Toys and sporting goods	
3901[2]	Other miscellaneous manufacturing industries	
39	MISCELLANEOUS MANUFACTURING Subtotal	
	OTHER IDENTIFIED END USES (Specify)	
	UNIDENTIFIED END USES	
	TOTAL	

[1]Corresponds to Division A, "Agriculture, Forestry, and Fishing"; 01 is used to avoid alphanumeric coding.

[2]This is not an SIC Code. Subscript 01 is added to a 2-digit code to report all other shipments to that 2-digit category, except those 3- and/or 4-digit categories specified.

Separation of Other Uses To Prevent Overaggregation

In quantitative questionnaires, a category such as "all other" is useful to capture all the miscellaneous categories of consumption not included among those separately listed. In the canvass forms designed for the end-use data collection system, this miscellaneous "all other" category is kept as small as possible.

For example, a firm that ships hot-dip galvanized products to the category Transportation may sell the bulk of these shipments to automobile manufacturers (SIC 3714). The same firm may also sell products to other transportation equipment manufacturers, such as railroad equipment and shipbuilding, neither of which may be individually significant, although they may be significant collectively.

If automobiles, railroad equipment, and shipbuilding were each separately listed, there would be three end-use categories for Transportation, which adds length to the form while in this case only adding trivial data. Moreover, the significance test should not be violated, or the end-use classes will multiply rapidly. On the other hand, if the Transportation classification is limited to automobiles, the respondent's shipments to other types of transportation manufacturers would be reported in a general miscellaneous catchall category, "All other."

To avoid such overaggregation into a general miscellaneous category, a method was developed wherein a coded "other" category is provided for each SIC two-digit group (for example, 3701, Other Transportation). This means that the residuals appropriate for each two-digit major group can be separately reported. This insures, at the two-digit level, that information is as accurate as could be expected.

However, such liberty within SIC numbering causes a conflict with SIC itself. In the SIC system, there are miscellaneous categories. All the categories not specified elsewhere for a two-digit category ordinarily are classified within a three-digit category in which the last digit is a 9. Thus, SIC 359 is Miscellaneous Machinery, Except Electrical. This methodology of using 9 is also repeated at four-digit levels, such as with SIC 3589, Service Industry Machines, Not Elsewhere Classified. The existence of categories such as 359 complicates the problem. Because SIC 359 is defined in SIC to include only the miscellaneous machinery specifically mentioned in the SIC manual, the use of an XX9 category for a general miscellaneous category would be misleading for our purpose.

What is needed instead is a true "all other" category to capture shipments not only to SIC 359, but also to all other three-digit categories not specified within 35X in the survey form, such as 354, 356, or 357. The special codings such as 3501 were developed by Penn State as a solution to this problem. The "01" is suffixed to an SIC two-digit category, such as SIC 35, to provide a place to report shipments to that particular SIC two-digit category rather than to the three-digit groups or four-digit industries separately specified in each questionnaire. This solves the problem.

To return to the previous example, the questionnaire asks the hot-dip galvanizer to report shipments to SIC 3714, Motor Vehicle Parts and Accessories, and to 3701, Other Transportation Equipment. This format insures that (1) data are accurate at the two-digit level and (2) a single catchall miscellaneous category will not overwhelm the data base. However, in a technical sense, 3701 is not an SIC category. The "01" coding concept is used because no such code exists in SIC; hence, its use will not conflict with any of the existing SIC categores.

Consider two firms conducting hot-dip galvanizing, and that although one firm is identical to the above case, the other is a firm that for some reason (because it sells through a sales agency or is otherwise unable to make a

determination of a customer's activity) does not know what portion of its shipments is consumed in "automobiles" versus "other transportation equipment." However, the firm can report how much is consumed in all "transportation equipment." The above-suggested format allows the second firm to report its data aggregated at the suggested level, without forcing it to report at a level of detail at which it is incapable of reporting. the example below shows how the second firm will report its "other" shipments on the line, SIC 3701.

SIC code	Description of end-use industry	Shipments (example)
37	TRANSPORTATION EQUIPMENT	
3714	Motor vehicle parts and accessories	
3701	Other transportation equipment	120
37	TRANSPORTATION EQUIPMENT Subtotal	120

If for a different commodity, for example, aluminum, shipments to both motor vehicles and aircraft and parts are significant, the questionnaire can be designed as shown below:

SIC code	Description of end-use industry	Shipments (example)
37	TRANSPORTATION EQUIPMENT	
371	Motor vehicles and equipment	80
372	Aircraft and parts	10
3701	Other transportation	10
37	TRANSPORTATION EQUIPMENT Subtotal	100

Note that in both cases the two-digit (SIC 37) information provides a good total. This flexible questionnaire design format allows collection of data for shipments to specific three-digit and four-digit SIC categories, the significance of which varies among minerals. The format captures all residual shipments to the SIC two-digit code categories specified for each mineral commodity and also provides reliable data at the SIC two-digit level for all mineral commodities.

The design of a survey questionnaire also includes a few categories that are not SIC-coded end uses. Of these, "Other Identified End Uses (Specify)" is a category specifically inserted in an effort to induce a respondent firm to report shipments to an end use not otherwise included on the questionnaire but which is significant for that particular respondent firm. The respondent is expected to briefly identify that special end-use sector in such instances. Space is provided on the questionnaires for this purpose. This category, "Other Identified End Uses," also provides for respondent firms to report shipments to new end uses as they arise.

The additional questionnaire categories "Other Unidentified Shipments," "Exports," etc., are self-explanatory. Whenever interfirm sales are common in an industry, provision is also made to report such sales.

Questionnaires are designed so that firms report their shipments by weight, because quantity data are needed to link the intermediate product to the contained weight of the mineral and, therefore, to U.S. mineral requirements. However, there may be special situations such as metal carbides for which the weight of material sold is so small that some firms maintain records only on the basis of dollar sales. In such instances, data can be collected by the Bureau on the basis of dollar sales, provided the

survey form also requires the firm to supply a conversion factor to convert the dollar sales figures into a measure of contained mineral. This conversion factor of necessity will have to be an average for each respondent of all his/her products and for all the sales contained in the special TPC. Because prices may fluctuate from time to time, the firm should be asked to report the conversion factor for each year in such cases. But collection of end-use data on a dollar sales basis is a poor approximation of the desired end-use data by weight. Hence, monetary values should be resorted to only when absolutely necessary.

A Modified Survey Form

The design of the typical survey form discussed in the previous section is flexible enough to be adapted to the particular information needs of an unusually complex mineral market. Table 7 is a canvass survey form designed for surveying producers of high-temperature alloys that contain many minerals.

The survey form for high-temperature alloys consists of a Work Sheet that is retained by the respondent and a Reporting Form submitted to the Bureau. Each of these sheets is further subdivided into Section I, Average Nominal Composition of High-Temperature Alloys Produced, and Section II, Shipments by End Uses. Section II of the reporting form is identical in all respects to the general case discussed earlier. The reasons for the differences between the Work Sheet and the Reporting Form are explained below.

Section I provides space for respondent firms to report a weighted average of the composition of each firm's product mix. This feature is designed to improve the information base that is used to link the demand for the primary metals to end-use sectors. Entries in section I are coefficients for various metals, as discussed earlier. Section I provides space for the respondent to estimate the amount of cobalt, chromium, and other ferroalloy metals incorporated in the products shipped to various end-use sectors.

Information reported in section I considerably minimizes the problems associated with the use of an average coefficient for purposes of mineral end-use estimation. This is because, although high-temperature alloys are a very divergent group of alloys, firms in the industry tend to specialize in a limited range of products. This fact was used in the design of the survey form so that, by directing each respondent firm to report the average composition relevant to itself, the average metal composition for all firms can be brought as close as possible to true average for all metal contained in the total product shipped to an end-use sector. In other words, by suitably designing the survey form, the Bureau can obtain an average measure of contained cobalt that is unique to the particular product mix of each firm instead of using a national average coefficient to allocate cobalt for all high-temperature alloys. This measure is also linked to the relevant end-use markets for the particular product mix.

Section II of the Work Sheet is further segmented to parts A, B and C. This is done to insure more accuracy and more uniformity in reporting. Because respondents return the Reporting Form but retain the Work Sheet, the respondent can place confidential data on the Work Sheet in order to calculate data requested on the Reporting Form. (Note.--A distinction was made between the design of the Work Sheet and the Reporting Form. Some firms in the industry felt that the detailed exercise required to complete the Work Sheet would provide information that is confidential. The asymmetric design devised by Penn State means that confidential data need not be placed on the Reporting Form.)

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TABLE 7. - High-temperature alloys, end-use survey form

Retain in Files

WORK SHEET

HIGH-TEMPERATURE ALLOYS

(Including Corrosion-Resisting Superalloys)

SOLD OR USED BY END USES

Retain in Files

SECTION I

AVERAGE NOMINAL COMPOSITION OF HIGH-TEMPERATURE ALLOYS PRODUCED[1]

Fe	Cr	Co	Cb	Ni	Ta	W	V	OTHER[2] (SPECIFY)					

[1]A weighted average or best estimate. See Specific Instructions, paragraph 5.

[2]List any other nominal components and specify in the appropriate blocks.

SECTION II

SHIPMENTS BY END-USES

SIC CODE	END-USE INDUSTRY	PART A: SHIPMENTS[1] (lbs.)	PART B[2]: ALLOCATION OF NONCAPTIVE FORGE SHOP SHIPMENTS	PART C[3]: ALLOCATION OF NONCAPTIVE CASTING WORKS SHIPMENTS
	FABRICATED METALWORK			
3443	Boilers, Chemical Process Vats, Nuclear Reactors and Other Fabricated Platework			
348	Ordnance and Accessories			
34	FABRICATED METALWORK Subtotal			
	MACHINERY, EXCEPT ELECTRICAL			
3511	Gas Turbines and Turbine Generator Sets			
3519	Marine Turbine Engines and Turbine Generators			
354	Metalworking Machinery and Equipment			
3567	Industrial Process Furnaces			
3501[a]	Steam Turbine Generators for Electrical Utilities			
35	MACHINERY, EXCEPT ELECTRICAL Subtotal			
	TRANSPORTATION EQUIPMENT			
372	Aircraft and Parts			
3761	Guided Missiles, Spacecraft and Parts			
3764	Space Propulsion Units and Parts			
3701[b]	Other Transportation Equipment Not Elsewhere Classified			
37	TRANSPORTATION EQUIPMENT Subtotal			
384	Surgical, Medical and Dental Instruments and Supplies			
	OTHER IDENTIFIED END USES (Specify)			
	UNIDENTIFIED END USES			
	SHIPMENTS TO NONCAPTIVE FORGE SHOPS			
	SHIPMENTS TO NONCAPTIVE CASTING WORKS			
	EXPORTS		Exports	Exports
	TOTAL		Total-Noncaptive Forge Shops	Total-Noncaptive Casting Works

[1]Report all shipments by end-uses. Report shipments to Noncaptive Forge Shops and Casting Works in the lines specified at the bottom of the Form. See Specific Instructions paragraphs 9 & 10.

[2]Estimate the breakdown of Noncaptive Forge Shipments by end-uses. Shipments for which such estimates cannot be made should be reported in line "Unidentified End Uses." Part B of Section II's total should agree with "Shipments to Noncaptive Forge Shops" in Part A of Section II.

[3]Estimate the breakdown of Noncaptive Casting Shipments by end-uses. Part C of Section II's total should agree with "Shipments to Noncaptive Casting Shops" in Part A of Section II.

[a]Modified SIC Code - report only shipments for the end use specified. All miscellaneous shipments to Machinery, Except Electrical should be reported on line SIC 35 Machinery, Except Electrical, Subtotal.

[b]Modified SIC Code -- report all other shipments to Transportation Equipment except those reported above in SIC 372, 3761, and 3764.

REPORTING FORM

Return to the U.S. Bureau of Mines

☐ check if your firm reported on the AIS, form 16 series

HIGH-TEMPERATURE ALLOYS

(Including Corrosion-Resisting Superalloys)

SOLD OR USED BY END USES

SECTION I

AVERAGE NOMINAL COMPOSITION OF HIGH-TEMPERATURE ALLOYS PRODUCED[1]

Fe	Cr	Co	Cb	Ni	Ta	W	V	OTHER[2] (SPECIFY)					

[1]A weighted average or best estimate. See Specific Instructions, paragraph 5.

[2]List any other nominal components and specify in the appropriate blocks.

SECTION II

SHIPMENTS BY END-USES

SIC CODE	END-USE INDUSTRY	TOTAL SHIPMENTS (lbs.)
	FABRICATED METALWORK	
3443	Boilers, Chemical Process Vats, Nuclear Reactors & Other Fabricated Platework	
348	Ordnance and Accessories	
34	FABRICATED METALWORK Subtotal	
	MACHINERY, EXCEPT ELECTRICAL	
3511	Turbines and Line Generator sets	
3519	Marine Turbine Engines and Turbine Generators	
354	Metalworking Machinery and Equipment	
3567	Industrial Process Furnaces	
3501[a]	Steam Turbine Generators for Electrical Utilities	
35	MACHINERY, EXCEPT ELECTRICAL Subtotal	
	TRANSPORTATION EQUIPMENT	
372	Aircraft and Parts	
3761	Guided Missiles, Spacecraft and Parts	
3764	Space Propulsion Units and Parts	
3701[b]	Other Transportation Equipment	
37	TRANSPORTATION EQUIPMENT Subtotal	
384	Surgical, Medical and Dental Instruments and Supplies	
	OTHER IDENTIFIED END USES (Specify)	
	UNIDENTIFIED END USES	
	EXPORTS	
	TOTAL	

SECTION III

SHIPMENTS TO NONCAPTIVE FORGE SHOPS[3] _____

SHIPMENTS TO NONCAPTIVE CASTING WORKS[4] _____

[a]Modified SIC Code - report only shipments for the end use specified. All miscellaneous shipments to Machinery, Except Electrical should be reported on line SIC 35 Machinery, Except Electrical, Subtotal.

[b]Modified SIC Code -- report all other shipments to Transportation Equipment except those reported above in SIC 372, 3761, and 3764.

[3]Total shipments to independent forgers.

[4]Total shipments to independent casters.

High-temperature alloys are not always sold directly to the customers by the producing firms. Often, shipments are made to intermediate fabricators, such as forge shops or casting works. During the case study on high-temperature alloys, several firms insisted that forge shops and casting works be designated as end-use markets for high-temperature alloys. This would have caused serious dilution of the end-use information. Furthermore, it would also have allowed those firms in the industry that did not want to report market details to report ambiguously much of their shipments as going to forge shops and casting works. They could do this despite the fact that sales practice in the industry is such that end-use destinations are rather well-known to producers through customer and product identification. Also, there was no guarantee that all the firms in the industry would report data in the same manner, because the more concientious firms would report estimates shipments to end-use sectors, while other firms might not do so.

All these complications were avoided by providing a Work Sheet that allows each respondent firm to record the firm's direct shipments to end uses in part A. Part A of the Work Sheet also lists noncaptive forge shops and noncaptive casting works as two quasi end uses. Part B of the Work Sheet directs the firms to show shipments made directly to forge shops in terms of the end-use markets that the firm estimates for their forge shop customers. Part C does the same for shipments made to casting works. The horizontal summation for each row across parts A, B, and C then gives the total shipments by each respondent to each SIC end-use market. For example, the quantity shipped to SIC 372, Aircraft and Parts would be the sum of the quantities shown for the SIC 372 row on part A, part B, and part C of the Work Sheet. This total is then entered for SIC 372 on the Reporting Form, which is returned to the Bureau.

This survey form, which is unique to high-temperature alloys, also points to the cost effectiveness of the two-dimensional information system now being introduced by the Bureau. Such a two-dimensional approach would enable the Bureau of Mines to collect, by means of one annual canvass, all the relevant information for eight or more metals without any loss of accuracy. If instead, the information system was designed for each primary metal, there would be a minimum of eight separate canvasses, one each for each metal specified in section I of table 7.

Lead: An Example of a New SIC-Based Survey Form

Table 8 shows section 4 of the Bureau of Mines' 1978 revision of the lead survey form.[10] Section 4 provides an example of an SIC-based replacement of an older Bureau form. The old format of section 4 of the previous survey form is shown in table 9. The new format represents a compromise between the standard format recommended by Penn State for end-use questionnaires and the desire of the Bureau's analysts to have historical continuity with statistics derived from the earlier form; thus, the format shown in table 8 should be considered an intermediate step to the general SIC format recommended for the Bureau's end-use questionnaires.

The new format differs from the old primarily in having two new columns inserted after the first column, "Intermediate products." The two new columns are labeled "SIC Code" and "End-use industries," column 2. The next column, "ADP Code," serves merely as numerical identification for data processing clerks. The last four columns--"Soft lead" (201) to "Lead in copper-base scrap" (204)--are identical to the last four columns in the older lead survey.

[10]Lead Secondary Smelter and Consumer Report" (Form 6-1108-MA, Nonfer.).

TABLE 8. - Revised lead survey form

4. Consumption of lead by class of product and end-use industry (Short tons of lead content)

Intermediate products (1)	SIC Code	End-use industries (2)	ADP Code	Soft lead (201)	Lead in antimonial lead (202)	Lead in alloys (203)	Lead in copper-base scrap (204)
METAL PRODUCTS:							
Ammunition	3482	Shot	301				
	3482	Bullets	302				
Bearing metals	35	Machinery except electrical	304				
	36	Electrical and electronic equipment	305				
	371	Motor vehicles and equipment	306				
	3701 1/	Other transportation equipment	307				
Brass and bronze-ingots, billets	3351	Brass and bronze	309				
Cable covering	361	Power cable	310				
	3661	Communication cable	311				
Calking lead	15	Building construction	313				
Casting metals (die, permanent mold, and slush-weights and ballast)	36	Electrical machinery and equipment	314				
	371	Motor vehicles and equipment	315				
	3701 1/	Other transportation equipment	316				
	3443	Nuclear radiation shielding	317				
Pipes, traps and other extruded products	15	Building construction	319				
	3443	Storage tanks, process vessels, etc	320				
Sheet lead	15	Building construction	322				
	3443	Storage tanks, process vessels, etc	323				
	3693	Medical radiation shielding	324				
Solder	15	Building construction	326				
	341	Metal cans and shipping containers	327				
	367	Electronic components and accessories	328				
	3601 1/	Other electrical machinery and equipment	329				
	371	Motor vehicles and equipment	330				
Storage battery grids, posts, etc. metal	36911	Storage batteries-SLI automotive	332				
	36912	Storage batteries-industrial and traction	333				
Storage battery oxides	36911	Storage batteries-SLI automotive	335				
	36912	Storage batteries-industrial and traction	336				
Terne metal	371	Motor vehicles and equipment	338				
Type metal	27	Printing and allied industries	339				
Other metal	34 1/	Other metal products	340				
PIGMENTS:			342				
Red lead and litharge (for other than storage batteries)	285	Paints	343				
	32	Glass and ceramic products	344				
	281	Color	345				
	28	Other pigments					
CHEMICALS:							
Lead alkyls	2911	Petroleum refining	347				
MISCELLANEOUS USES: *(please specify)* 2/			350				
		TOTAL	399				

1/ This is not an SIC product class-01 is added to a 2-digit code to report other consumption.
2/ Includes collapsible tubes, foil, annealing, galvanizing, plating and fishing weights.
3/ Includes powder, rubber and plastic additives, anodes, steel products, etc.

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TABLE 9. - Old lead survey form

4. Consumption of lead by class of product (Short tons of lead content)

Products (1)	Code	Soft lead (201)	Lead in antimonial lead (202)	Lead in alloys (203)	Lead in copper-base strip (204)
METAL PRODUCTS:					
Ammunition – billets, shot, wire	301				
Bearing metals (avg. ___% Sb)	302				
Brass and bronze ingot	303				
Cable covering and sleaving (avg. ____% Sb)	304				
Calking lead	305				
Casting metals (die, permanent mold, and slush)	306				
Collapsible tube blanks, disks	307				
Foil	308				
Pipes, traps, and other extruded products	309				
Sheet lead	310				
Solder	311				
Storage battery grids, posts, etc., of Sb-Pb (avg. ____% Sb)	312				
Storage battery oxides	313				
Terne metal	314				
Type metals (avg. ____% Sb)	315				
PIGMENTS:					
White lead	317				
Red lead and litharge (for other than storage batteries)	318				
Other *(please specify)*	319				
CHEMICALS:					
Lead alkyls	321				
Lead arsenate	322				
Other *(please specify)*	323				
MISCELLANEOUS USES:					
Annealing	325				
Galvanizing	326				
Lead plating	327				
Weights and ballast	328				
OTHER USES *(please specify)*	329				
TOTAL	399				

Signature	Title	Date

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A major difference between section 4 of the 1978 lead survey form and the SIC survey forms proposed for other commodities is the rigidity of the end-use classifications of the new lead survey. In the revised lead survey, each respondent firm is asked to report its shipments to the selected few end uses specified for each intermediate product. There is no provision in this intermediate form to improve the accuracy by accumulating data at SIC two-digit levels.[11] The reasons for the intermediate form are fully detailed in the appendix to Chapter XII, Lead, in Penn State's September 1978 report, "SIC Based End-Use Scheme for Information Critical Minerals" (28).[12]

A Statistical Sampling Alternative

An alternative to a comprehensive industry canvass is to use a suitable sampling method to estimate statistically valid data for industry shipments. If feasible, this method can reduce the cost of the survey and reduce the reporting burden on the industry. A sampling approach is particularly suited to those atomistic industries that serve largely regional markets.

A pilot study of steel service center shipments was conducted by Penn State to determine the feasibility of a survey sampling about 10 percent of establishments in this particular industry. The results were mixed. On one had, the study proved that a stratified random sampling both is feasible and can provide valid results for SIC-based end-use data, even when the respondent firms are not well acquainted with SIC. On the other hand, the study also showed that even an intensive effort that involved two separate mailings and extensive telephone canvassing was not sufficient to persuade firmsin this industry to participate in the voluntary canvass.

In the case of steel service centers, it was possible to design a sampling method, but it was impossible to implement the scheme. The respondent firms often serve narrow, local markets and focus on present customers. They did not perceive sufficient benefits for themselves from nationally oriented, SIC-based data to complete the canvass. The voluntary sample survey of steel service centers produced only a 20-percent response, an inadequate basis for drawing statistically valid conclusions.

Integrating Data From Other Sources Into the SIC-Based Information System

Several trade associations, such as the American Iron and Steel Institute, Copper Development Association, and Aluminum Association, collect end-use data periodically from their member firms. For the SIC-based information system proposed in this study to be cost effective, it was necessary to examine whether end-use data that are now available from such associations could be integrated into the SIC-based information system.

Reports of end-use data published by trade associations tend to be issued very promptly and usually in such detail that the data completely satisfy the information system proposed in this study. Until now, the use of such data has been inhibited by two major considerations. First, each trade association follows a market classification of its own, apparently suited to the particular needs of the trade group involved. Therefore,

[11] Penn State carried out a study on an SIC-based end-use data scheme for U.S. lead in the summer of 1976. Two alternative survey forms were proposed in that study. The Lead Industries Association (LIA), which cooperated with the Penn State study, however, wished to have a more detailed product to end-use classification scheme. The alternative form, shown in Penn State's 1978 report, reflected LIA's concern for details and was more consistent with the standard format of end-use questionnaires.

[12] Underlined numbers in parentheses refer to items in the bibliography preceding the appendixes at the end of this report.

data from different trade associations for different materials are not gathered on a comparable basis.

Second, until now, information from trade associations has been dissemenated only to the member firms and generally has not been available to the Government or the public. Even when trade association data are provided to the public, the data are often released after major aggregations or other recasting, so that the published information is not comparable to SIC. For example, the Copper Development Association (CDA) published data on annual consumption of copper in five major end-use markets. But the CDA itself collects data from brass mills on shipments to 54 "end uses" and for 4 different products. The CDA combines its primary data for brass from the 54 end uses with estimates of copper wire mill shipments, and only these aggregated data are provided to the public.

However, if the data that are made available by trade associations can be integrated into an SIC-based information system, the public interest would be served. Hence, the attempt is made in the Bureau's new end-use reporting system to use trade association data whenever such data are available.

To achieve the above objective, it is essential to "correlate" the trade association classification with SIC. Such attempts at correlation were made unsuccessfully in the past by the American Iron and Steel Institute, International Nickel Company (for steel), and Copper Development Association (for brass mill shipments).

Table 10 illustrates the reason for the failure of these industry efforts to correlate existing market classifications with SIC. CDA 310, Automotive Non-electric, consists of the 95 items listed in table 10, but CDA 310 itself is but one of the 54 CDA end uses. CDA has defined the 310 "end use" to include products such as automotive hardware, piston rings, and passenger car bodies, as described in column 2. As shown in column 1, CDA then proceeded to identify each one of these products with the SIC four-digit industry or five-digit SIC-based product class that described these products.

Column 1 of table 10 shows that CDA end-use category 310 cannot be identified with one unique SIC code. Automotive Hardware is produced by firms in SIC 3429, Piston Rings in SIC 3529, Passenger Car Bodies in SIC 3711, and so on. Because each of these examples belongs to three entirely different SIC two-digit major groups, the difference cannot be reconciled even at the two-digit major group level. Because of such extensive overlaps into different SIC groups and industries, CDA concluded that it is not possible to compare CDA end uses with SIC.

Two points should be noted here. First, CDA was not willing to redefine its end use 310 (and other end uses) in a way that would minimize the above problem. Instead, CDA attempted (and failed) to achieve a perfect one-to-one correlation between two entirely different classification systems. Second, this failure is not a sufficient indication that SIC is a poorly defined classification system. All that it indicated is that SIC is defined in a different manner than that utilized in CDA's classification system.

A reasonable basis for comparing such individualized industry classifications as that of CDA with SIC does exist, however, if such comparisons are made with SIC commercial uses.

TABLE 10. - CDA market classification, an example using CDA end-use 310, Automotive, Nonelectric

SIC No.	Description
3429 4.....	Automotive hardware.
3429 4.....	Bus hardware.
3429 4.....	Hardware, motor vehicle.
3429 4.....	Motor vehicle hardware.
3429 4.....	Truck hardware.
3465 0.....	Automotive trim.
3465 0.....	Grills, automotive radiator.
3465 0.....	Hubcaps, automotive.
3465 0.....	Trim, automotive body.
3519 1.....	Bus engines, diesel.
3519 1.....	Diesel engines, truck, bus, and auto.
3519 1.....	Truck engines, diesel.
3585 3.....	Air conditioners, auto, truck, and bus.
3585 3.....	Automotive air conditioners.
3585 3.....	Bus air conditioners.
3585 3.....	Truck air conditioners.
3592 0.....	Carburetors, automotive.
3592 0.....	Floats, carburetor.
3592 0.....	Piston rings.
3711 1.....	Ambulances, assembly.
3711 1.....	Assembly--cars, trucks, and buses.
3711 1.....	Bodies and body parts, automotive.
3711 1.....	Bodies, motor vehicle, other than truck or bus.
3711 1.....	Buses, assembly.
3711 1.....	Chassis, automotive, for sale separately.
3711 1.....	Fire engine assembly.
3711 1.....	Motor vehicle bodies, other than truck or bus.
3711 1.....	Motor vehicles, assembly.
3711 1.....	Passenger car assembly.
3711 1.....	Passenger car bodies.
3711 1.....	Taxicabs, assembly.
3711 1.....	Tractors, motor truck (highway), assembly.
3711 1.....	Truck tractors and trailers, assembly.
3711 1.....	Trucks, motor, assembly.
3713 0.....	Ambulance bodies.
3713 0.....	Bodies, truck and bus.
3713 0.....	Bus bodies.
3713 0.....	Cabs, for industrial trucks.
3713 0.....	Coach and bus bodies.
3713 0.....	Truck beds.
3713 0.....	Truck bodies.
3713 0.....	Truck cabs.
3713 0.....	Truck tops.
3714 1.....	Accessories, automotive, nonelectrical.
3714 1.....	Automobile parts and accessories, nonelectrical.
3714 1.....	Bearings and bushings, automotive.
3714 1.....	Brakes and brake parts, automotive.
3714 1.....	Bumpers, automotive.
3714 1.....	Bus engines, except diesel.
3714 1.....	Bus parts and accessories.

TABLE 10. - CDA market classification, an example using CDA end-use 310, Automotive, Nonelectric--Continued

SIC No.	Description
3417 1	Bushings, automotive.
3714 1	Clutches and parts, automotive.
3714 1	Cores, automotive radiator.
3714 1	Cores, tire valve.
3714 1	Disk brakes, automotive.
3714 1	Drum brakes, automotive.
3714 1	Engine bearings, automotive.
3714 1	Engines and engine parts, automotive.
3714 1	Filters, automotive.
3714 1	Fuel systems and parts, except carburetor.
3714 1	Gears, automotive.
3714 1	Governors, automotive.
3714 1	Headers, radiator, automotive.
3714 1	Heaters, automotive.
3714 1	Lubrication systems and parts, automotive.
3714 1	Motor vehicle parts and accessories, nonelectrical.
3714 1	Passenger car parts and accessories, nonelectrical.
3714 1	Pollution control equipment, automotive.
3714 1	Power steering and brakes, passenger car.
3714 1	Pumps, fuel and water, automotive.
3714 1	Radiator and parts, automotive.
3714 1	Rebuilding, motor vehicle engines, factory.
3714 1	Rebuilt engines and parts, automotive, except carburetors.
3714 1	Shock absorbers, automotive.
3714 1	Steering mechanisms, automotive.
3714 1	Strainers, gasoline, automotive.
3714 1	Tanks, radiator, automotive.
3714 1	Thermostats, automotive.
3714 1	Tire inflators, automotive.
3714 1	Tire valves.
3714 1	Transmission equipment, automotive.
3714 1	Truck engines, nondiesel.
3714 1	Valves, automotive, tire.
3714 1	Wheels and parts, automotive.
3715 0	Chassis, truck trailers.
3715 0	Horse vans.
3715 0	Semitrailers for truck tractors.
3715 0	Tank trucks.
3715 0	Trailers, motor truck.
3715 0	Truck trailers.
3715 0	Vans, freight.
7539 0	Automotive radiator repair shops.
7539 0	Automotive repair shops, n.e.c.
7539 0	Radiator repair shops.
7539 0	Repair shops, automotive, n.e.c.

Source: Copper Development Association, End-Use Classification Scheme for Copper and Copper Alloy Mill Products, 1977.

Consider again the previous example of CDA category 310, Automotive, Non-Electric. This category represents consumption of copper and copper alloys in nonelectric uses in motor vehicles. The appropriate end-use sector then is motor vehicles. Irrespective of whether a particular product is produced by a metal fabricator or an automotive plant,[13] the material is consumed in the manufacture of motor vehicles. Therefore, SIC 371, Motor Vehicles, correlates extremely well with CDA 310. In other words, the quantity of copper used in CDA 310 is consumed in the production of motor vehicles, whether we choose to designate the consumption in terms of SIC or in terms of DCA classification. In this explanation, then, we have a basis to compare CDA's classification system with the Bureau's SIC-based system.

The above example was meant to show the basic reason for the failures of past industry attempts, as well as to explain that within the objectives of the present study, it is highly probable that industry data can be integrated into an SIC-based information system without a significant loss in accuracy. This logic assumes, for example, that a brass producer will report the same tonnage when he is asked to report shipments for consumption in motor vehicles, whether or not motor vehicles are described as CDA 310 or SIC 371.

It should also be noted that the quantity shown for 310 in CDA's own data base tells the industry only the consumption of brass mill products for automotive use. There is no reason why these product listings have to be viewed differently when the data are analyzed in terms of SIC. The above example shows that, at least as a first approximation, it is possible to correlate a trade association's end-use categories with SIC-defined end uses, even when there does not appear to be a one-to-one correlation between the two classifications.

Table 11 provides a means to translate the CDA 54 end-use categories into a minimum number of SIC categories. The CDA 54 end-use categories are regrouped in terms of 19 SIC categories using the following criteria: (1) Significant volume of shipments as indicated by available data on brass mill shipments, (2) the clarity of data at the SIC two-digit major group level, and (3) the desirability of a list of end uses common for both brass mill and wire mill shipments.

The format of table 11 collapses to 19 the number of SIC end uses that correspond to the 54 CDA end uses. In table 11, CDA data for 1972 brass mill shipments are used as a measure of the volume of shipments. Column 3 lists the percent of brass mill shipments demanded in each SIC category specified. The reader also should be aware that brass mill shipments are but one part of copper shipments, which are what the Bureau wishes to measure.

This brass-copper relationship is the reason that a major exception to the volume cutoff point apparently is made in the choice of SIC end uses in electrical and electronic equipment. Among SIC 361, 362, or 366, none is critical if considered on the basis of volume of brass shipments. These three SIC categories are critical for end-use data relating to copper wire mill products and are, therefore, retained. The percentages shown in table 11 are misleading because they pertain only to brass mill shipments.

Another major exception that is made in table 11 is the inclusion of SIC 38, Instruments and Related Products. This item is included to insure clarity of data at the SIC two-digit level.

[13] The producing industry is the basis used by CDA for assigning the SIC numbers shown in table 10, column 1.

TABLE 11. - Recommended translator for converting CDA data into SIC data base

SIC code	SIC description	Brass shipments, percent of total	Corresponding CDA end uses	
			CDA code	CDA Description[1]
15	Construction.....	3	190	Other construction.
			522	Onsite heat exchangers.
33	Primary metal industries.....	6	910	Rerollers and redrawers.
34	Fabricated metal products:			
343	Heating and plumbing.....	6	130	Plumbing and heating.
345	Screw machine products.....	10	610	Fasteners.
			810	Screw machine products.
346	Metal forging and stamping..	6	820	Forging.
			830	Stamping.
348	Ordnance.....	6	760	Ordnance.
3401	Other fabricated metal products.	9	110	Builders' hardware (342).
			120	Architectural products (344).
			521	Industrial heat exchangers (344).
			530	Industrial valves and fittings (349).
			230	Utensils and plated ware (3401).
			290	Other household products (3401).
			890	Other component parts (3401).
	Subtotal.....	37		
35	Nonelectrical machinery:			
358	Refrigeration.....	6	140	Cooling.
3501	Other machinery.....	4	529	Other heavy industrial equipment.
	Subtotal.....	10	590	Other industrial machinery and equipment.
36	Electrical and electronic equipment:			
361	Electrical transmission and distributing equipment.	1.5	421	Transformers.
			422	Switchgear and industrial circuit breakers.
362	Electrical industrial apparatus.	2	410	Motors and generators.
			423	Industrial controls.
			429	Other electrical distribution and control.
366	Communication equipment.....	1.5	431	Telecommunications.
3601	Other electrical and electronic equipment.	7	210	Major appliances except air conditioners (363).
			220	Portable appliances (363).
			440	Wiring devices, lamp shell, and sockets (364).
			432	Electronics and other communication (3601).
			490	Other electrical and electronic products (3601).
	Subtotal.....	12		
	Transportation equipment:			
371	Motor vehicles.....	13	310	Automotive, except electrical.
			320	Automotive, electrical.
3701	Other transportation.....	1	330	Marine.
			390	Other transportation.
	Subtotal.....	14		
38	Instruments and related products.	1	710	Timing devices (387).
			740	Instruments, except electrical measuring (3801).
	Miscellaneous manufacturing industries:			
396	Jewelry, notions, buttons, closures.	2	620	Closures.
			730	Jewelry.
3901	Other miscellaneous manufacturing industries.	2	790	Other uses.
	Subtotal.....	4		
	Other identified end uses:			
	Distributors.....	12	920	Distributors.
	Exports.....	1	930	Export.
	Grand total.....	100		

[1]Numbers in parentheses indicate appropriate SIC codes for CDA end uses grouped together in this translator for convenience.

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Table 11 retains (1) all the major SIC end-use sectors relevant for copper and copper alloys and (2) the benefits of an end-use classification that is common for both wire mill (copper) and brass mill products. Also, since the end-use categories in table 11 are aggregated, there is less need for concern about the confidentiality of the source information. This was a problem that precluded direct use of CDA's 54-end-use data base.

IMPLEMENTATION OF THE DATA SYSTEM

The practical aspects of the implementation of the SIC end-use data system were first tested using sulfur. After an industrywide trial run of the survey form to elicit industry comments and suggestions, the scheme for sulfur was implemented in 1976.

The initial work was followed by an extended study to cover all information-critical minerals. Studies were completed for the following mineral commodities:

Aluminum	Mercury
Antimony	Mica
Asbestos	Nickel
Bismuth	Rare earths
Cadmium	Sulfur
Chromium	Tantalum
Cobalt	Tin
Columbium	Titanium
Copper	Tungsten
Fluorine	Vanadium
Iron and steel	Zinc
Lead	

Together, these 23 mineral commodities represent a total of 42 technical product classes (ferrous minerals, 18; nonferrous minerals, 17; and nonmetals, 7).

Table 12, which is similar in concept to the traditional transaction matrix of an input-output table of the economy, lists the 42 TPC's and the SIC end uses relevant for each.

In such a table, the column entries would represent the input of each TPC in the production of goods in SIC-based commercial uses, and the column totals would represent the total consumption of TPC's in the production of all domestic goods. Similarly, the row (line) entries would indicate the demand for the various TPC's in each SIC commercial use.

Table 12 here consists of three pages; in reality it should be one sheet of 42 TPC columns (beginning with "carbon steel" and ending with "asbestos") and 71 end-use rows (beginning with SIC 01, Agriculture and ending with SIC 39, Miscellaneous Manufacturing Industries).

The ratio of each actual entry in the table 12 matrix to the total output of the corresponding SIC commercial use yields the intensity-of-use of a TPC in that SIC commercial use. In the section "Symbolic Definition of Technical Product Classes" equation 4 was given. This equation can be used to calculate the intensity of use of a mineral as a function of the intensity of use of its TPC's. It was also shown how properly specified TPC categories (the X's and Z's of figure 1) could be combined to yield a reasonable approximation of the intensity-of-use of a mineral (M) in SIC commercial uses. In other words, when the data system is in place for all minerals, it will be possible to construct a second matrix similar to the one in table 12 with minerals as columns instead of TPC's, thus providing an intensity-of-use matrix for different minerals in SIC commercial uses.

Many of the data needed to construct the matrix in table 12 are not now collected by the Bureau. The purpose of the new data system is to gather, for the first time, information leading to the construction of such a matrix.

The end-use data for the 42 TPC's in table 12 can be obtained by the Bureau with a minimum of additional canvasses.[14] Other than the new survey forms already in use for sulfur, only three

[14] See appendix B for references to specific commodity studies.

new canvasses are needed: (1) High-temperature alloys, (2) magnetic alloys, and (3) carbides and hard-facing alloys. These three TPC's are common for a number of ferrous minerals, yet no end-use data are at present collected for them.

Data for all other TPC's can obtained either by translating currently available data into the SIC end-use format or by modifying existing Bureau canvasses.

The statistics will be collected from the producers of the various TPC's on an annual basis. Annual collection reduces the burden on the reporting firms and also avoids the necessity for data on inventories. The annual time horizon implies that "shipments" are more likely to coincide with "consumption" than is the case with the monthly and quarterly data of many of the Bureau's current statistical reports.

When fully implemented, the two-dimensional TPC end-use matrix shown in table 12 will for the first time provide and complete input-output matrix of material consumption in SIC end-use sectors. The table entries will help in improving the forecasting of the demand for materials (TPC's), given forecasts of economic actibity in the specified end-use sectors.

The matrix in table 12 also will yield data over time useful in identifying the intensity-of-use of TPC's in various end uses, as well as the substitution between different technical product classes in the same end-use sectors. The new data system of the Bureau will constitute a major step in gaining a better understanding of the nature of demand for minerals in the economy.

TABLE 12. - TPC end-use matrix for information-critical minerals

(X's indicate data that will be available when implementation of the data system is complete)

SIC code	End-use industries	Carbon steel	HSLA steel	Alloy steel	Tool steel	Stainless steel	High-Temp. alloys	Magnetic alloys	Carbides and hard facing	Columbium-tantalum	Chromium compounds	Refractory chromite	Cobalt compounds	Cobalt metal	Nickel plating	Nickel alloys	Nickel compounds	Tungsten	Titanium	Vanadium	Aluminum	Copper (wire mill)
01	Agriculture	X	X	X	X	X																
10	Mining	X	X	X	X	X															X	X
15	Building construction	X	X	X	X	X													X		X	X
16	Heavy construction	X	X	X	X	X											X					
20	Food and kindred products																		X			
22	Textile mill products														X						X	
25	Furniture and fixtures	X	X	X	X	X					X								X			
26	Paper and allied products										X											
27	Painting									X	X		X							X		
281	Industrial inorganic chemicals									X	X	X										
282	Plastics, materials, and synthetics										X									X		
283	Drugs										X											
284	Soap, cleaners, and toilet goods										X		X						X	X		
285	Paints and allied products									X								X		X		
286	Industrial organic chemicals										X		X		X		X	X	X	X		
287	Fertilizers and agricultural chemicals										X		X					X	X	X		
289	Explosives and miscellaneous chemical products									X	X	X	X		X		X	X	X	X		
28	Chemicals and allied products												X					X	X	X		
291	Petroleum refining												X				X	X	X	X		
29	Petroleum and coal products										X											
30	Rubber and miscellaneous plastics products										X											
31	Leather and leather products																					

SIC code	End-use industries	Brass	Zinc die castings	Hot-dip galvanized steel	Zinc, rolled	Zinc compounds	Lead	Silver	Mercury	Antimony	Magnesium metal	Magnesium compounds	Rare earths		Cadmium	Fluorspar	Fluosilicic acid	Hydrofluoric acid	Sulfur	Sulfuric acid	Mica	Asbestos
01	Agriculture			X		X			X													
10	Mining																					X
15	Building construction	X		X			X				X											
16	Heavy construction			X																		
20	Food and kindred products					X				X		X							X			
22	Textile mill products																					
25	Furniture and fixtures		X	X						X		X							X	X		
26	Paper and allied products						X			X					X							
27	Painting				X	X		X		X					X	X	X	X	X	X		
281	Industrial inorganic chemicals					X			X	X		X			X			X	X	X		
282	Plastics, materials, and synthetics								X			X		X					X	X		
283	Drugs					X						X		X					X	X		
284	Soap, cleaners, and toilet goods						X		X									X	X	X		
285	Paints and allied products										X								X	X		
286	Industrial organic chemicals								X			X				X	X		X	X		
287	Fertilizers and agricultural chemicals					X				X	X	X		X	X	X	X	X	X	X		
28	Chemicals and allied products					X	X	X	X	X	X	X						X	X	X		
291	Petroleum refining						X						X					X	X	X		
29	Petroleum and coal products					X	X			X		X							X	X		
30	Rubber and miscellaneous plastics products																					
31	Leather and leather products																					

TABLE 12. - TPC end-use matrix for information-critical minerals --Continued

(X's indicate data that will be available when implementation of the data system is complete)

SIC code	End-use industries	Carbon steel	HSLA steel	Alloy steel	Tool steel	Stainless steel	High-temp. alloys	Magnetic alloys	Carbides and hard facing	Columbium-tantalum	Chromium compounds	Refractory chromium	Cobalt compounds	Cobalt metal	Nickel plating	Nickel alloys	Nickel compounds	Tungsten	Titanium	Vanadium	Aluminum	Copper (wire mill)
321	Glass										X		X									
324	Cement										X	X										
325	Structural clay products										X		X									
326	Ceramics																					
329	Abrasives and miscellaneous products										X											
32	Glass, ceramics, and clay products										X	X	X				X		X			
331	Steel mills	X	X	X	X	X						X								X		
332	Iron and steel foundries											X										
333	Primary nonferrous metals																		X	X		
334	Secondary nonferrous metals									X												
335	Nonferrous rolling and drawing									X		X							X	X		
33	Primary metal industries	X	X	X	X	X													X	X		
341	Metal cans and containers	X	X	X	X	X															X	
342	Cutlery, hand tools, and hardware	X	X	X	X	X							X		X							X
343	Plumbing and heating	X	X	X	X	X										X						
344	Fabricated structural products	X	X	X	X	X	X		X						X	X				X	X	
345	Screw machine products	X				X									X							X
346	Metal forgings and stampings	X				X			X												X	
347	Plating, coating, and polishing							X			X			X			X		X			
348	Ordnance	X	X	X	X	X	X		X									X			X	X
349	Miscellaneous fabricated metal products													X	X							
34	Fabricated metal products	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X
351	Engines and turbines	X	X	X	X	X	X		X							X						X
352	Farm and garden machinery	X	X	X	X	X			X							X						
353	Construction machinery	X	X	X	X	X		X	X							X						

SIC code	End-use industries	Brass	Zinc die castings	Hot-dip galvanized steel	Zinc, rolled	Zinc compounds	Lead	Silver	Mercury	Antimony	Magnesium metal	Magnesium compounds	Rare earths	Bismuth	Cadmium	Fluorspar	Fluosilicic acid	Hydrofluoric acid	Sulfur	Sulfuric acid	Mica	Asbestos
321	Glass												X			X	X	X				
324	Cement											X										
325	Structural clay products					X												X				
326	Ceramics					X										X		X				
329	Abrasives and miscellaneous products											X	X									
32	Glass, ceramics, and clay products					X	X	X		X		X	X		X	X	X	X				
331	Steel mills						X				X		X	X		X		X		X		
332	Iron and steel foundries										X		X	X		X		X				
333	Primary nonferrous metals				X						X							X		X		
334	Secondary nonferrous metals													X		X	X	X				
335	Nonferrous rolling and drawing						X			X					X							
33	Primary metal industries				X		X			X	X		X	X	X	X	X	X		X		
341	Metal cans and containers			X			X				X											
342	Cutlery, hand tools, and hardware	X									X											
343	Plumbing and heating																					
344	Fabricated structural products			X	X		X											X				
345	Screw machine products	X																				
346	Metal forgings and stampings	X		X																		
347	Plating, coating, and polishing				X	X	X								X							
348	Ordnance	X	X				X			X												
349	Miscellaneous fabricated metal products			X			X			X	X											
34	Fabricated metal products	X	X	X	X	X	X			X	X							X				
351	Engines and turbines																					
352	Farm and garden machinery			X							X											
353	Construction machinery			X							X											

TABLE 12. - TPC end-use matrix for information-critical minerals --Continued

(X's indicate data that will be available when implementation of the data system is complete)

SIC code	End-use industries	Carbon steel	HSLA steel	Alloy steel	Tool steel	Stainless steel	High-Temp. alloys	Magnetic alloys	Carbides and hard facing	Columbium-tantalum	Chromium compounds	Refractory chromium	Cobalt compounds	Cobalt metal	Nickel plating	Nickel alloys	Nickel compounds	Tungsten	Titanium	Vanadium	Aluminum	Copper (wire mill)
354	Machine tools, dies, etc.	X	X	X	X	X	X		X						X	X		X				
355	Special industry machinery	X	X	X	X	X			X	X						X						
356	General industrial machinery	X	X	X	X	X	X		X							X						
357	Office and computing machines														X							
358	Refrigeration and service machinery	X	X	X	X	X										X					X	X
35	Nonelectrical machinery	X	X	X	X	X	X	X	X	X					X	X		X			X	X
361	Electric distributing equipment							X								X					X	X
362	Electrical industrial apparatus							X	X							X		X				X
363	Household appliances	X	X	X	X	X		X							X	X		X			X	X
364	Lighting and wiring equipment														X			X			X	X
365	Radio and TV receiving equipment							X														
366	Communication equipment	X	X	X	X	X		X													X	X
367	Electronic components							X		X								X				X
369	Batteries and miscellaneous equipment																	X				
36	Electric and electronic equipment	X	X	X	X	X		X	X	X				X	X	X	X	X	X	X	X	X
371	Motor vehicles and equipment	X	X	X	X	X		X	X	X				X	X	X		X	X	X		
372	Aircraft and parts	X	X	X	X	X	X		X						X	X		X	X	X	X	X
373	Ship building and repairing	X	X	X	X	X			X							X				X		
374	Railroad equipment	X	X	X	X	X			X											X		
376	Guided missiles, space vehicles, parts						X		X									X	X			
379	Miscellaneous transportation equipment																				X	
37	Transportation equipment	X	X	X	X	X	X		X						X	X		X	X	X	X	X
38	Instruments and related products						X	X	X					X	X	X		X	X	X	X	
39	Miscellaneous manufacturing industries	X	X	X	X	X	X		X	X					X						X	

SIC code	End-use industries	Brass	Zinc die castings	Hot-dip galvanized steel	Zinc, rolled	Zinc compounds	Lead	Silver	Mercury	Antimony	Magnesium metal	Magnesium compounds	Rare earths	Bismuth	Cadmium	Fluorspar	Fluosilicic acid	Hydrofluoric acid	Sulfur	Sulfuric acid	Mica	Asbestos
354	Machine tools, dies, etc.											X		X								
355	Special industry machinery			X																		
356	General industrial machinery							X		X		X		X								
357	Office and computing machines																					
358	Refrigeration and service machinery	X						X										X				
35	Nonelectrical machinery	X	X	X			X	X		X		X		X				X				X
361	Electric distributing equipment			X																	X	
362	Electrical industrial apparatus																				X	
363	Household appliances	X	X	X														X			X	X
364	Lighting and wiring equipment			X					X													X
365	Radio and TV receiving equipment		X																		X	
366	Communication equipment						X			X											X	
367	Electronic components					X	X								X							
369	Batteries and miscellaneous equipment				X		X	X	X	X					X					X		
36	Electric and electronic equipment	X	X	X	X	X	X	X	X	X		X	X	X	X			X		X	X	X
371	Motor vehicles and equipment						X				X											X
372	Aircraft and parts										X											
373	Ship building and repairing		X								X											
374	Railroad equipment																					
376	Guided missiles, space vehicles, parts																	X				
379	Miscellaneous transportation equipment																					
37	Transportation equipment	X	X	X			X				X							X				X
38	Instruments and related products	X	X					X	X					X							X	
39	Miscellaneous manufacturing industries	X	X	X	X			X					X									

BIBLIOGRAPHY

1. Aluminum Association. Aluminum Statistical Review. New York, 1974, 64 pp.

2. American Iron and Steel Institute. High-Temperature High Strength Alloys. Washington, D.C., 1963, 155 pp.

3. _____. Instructions for Reporting Steel Shipment Statistics. Washington, D.C., 1968, v. I-II.

4. Brooks, D. B., and P. W. Andrews. Mineral Resources, Economic Growth and World Population. Science, v. 185, No. 4148, 1974, pp. 13-19.

5. Callaway, M. Lead. A Materials Survey. BuMines IC 8083, 1962, 194 pp.

6. Centre d'Information de Cobalt. Cobalt Monograph. Brussels, 1960, 515 pp.

7. Charles River Associates. Economic Analysis of the Cobalt Industry. 1969, pagination varies; available from the National Technical Information Service, Springfield, Va., PB 195 821.

8. _____. Economic Analysis of the Lead-Zinc Industry. 1969, pagination varies; available from the National Technical Information Service, Springfield, Va., PB 183 483.

9. _____. Economic Analysis of the Nickel Industry. 1968, pagination varies; available from the National Technical Information Service, Springfield, Va., PB 182 696.

10. Cobalt Information Center. Cobalt Alloy Permanent Magnets. Battelle Memorial Institute, Columbus, Ohio, 1971, 82 pp.

11. _____. Cobalt-Base Super Alloys--1970. Battelie Memorial Institute, Columbus, Ohio, 1970, 72 pp.

12. Cole, H. S. D., et al. Models of Doom. Universe Books, New York, 1973, 244 pp.

13. Copper Development Association, Inc. Annual Data--Copper Supply and Consumption. New York, 1974-78.

14. _____. End-Use Classification Manual for Copper and Copper Alloy Mill Product Shipments. New York, 1977, 164 pp.

15. Environmental Science Services Corp. Economics of Sulfur Recovery From Fossil Fuels. Stamford, Conn., 1968, 47 pp.

16. Farmer, M. H., et al. Long-Range Sulfur Supply and Demand Model. 1971, 306 pp.; available from the National Technical Information Service, PB 286 063.

17. Farnsworth, M. A., and C. H. Kline. Zinc Chemicals. Zinc Institute, New York, 1973, 248 pp.

18. Hazleton, J. E. The Economics of the Sulphur Industry. Resources for the Future, Washington, D.C., 1970, 172 pp.

19. International Lead and Zinc Study Group. Lead and Zinc; Factors Affecting Consumption. New York, 1966, 83 pp.

20. Johnston, J. Econometric Methods. McGraw-Hill Book Co., New York, 2d ed., 1972, 437 pp.

21. Landsberg, H. H. Projections in Retrospect. Proc. Council of Economics, AIME, 1975, pp. 141-146.

22. MacKallor, J. A. The Supply and Demand of Lead for the United States Through 1983. Ph.D. Thesis, Pa. State Univ., 1976, 313 pp.

23. Malenbaum, W. Laws of Demand for Minerals. Proc. Council of Economics, AIME, 1975, pp. 147-155.

24. McGannon, H. E. (ed.). The Making, Shaping and Treating of Steel. United States Steel, Pittsburgh, Pa., 8th ed., 1964, 1300 pp.

25. McMahon, A. D., C. H. Cotterill, and J. T. Dunham. The U.S. Zinc Industry. BuMines IC 8629, 1974, 76 pp.

26. Meadows, D. H., et al. The Limits to Growth. New American Library, Inc., New York, 1972, 203 pp.

27. Nair, B. K., and G. K. Schenck. Design of Mineral End-Use Surveys. BuMines Open File Rept. 102-78, 1977, 189 pp.; available for consultation at the Bureau of Mines libraries in Juneau, Alaska, Denver, Colo., Reno, Nev., Pittsburgh, Pa., and Spokane, Wash., and at the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C.; copies available from Pa. State Univ., University Park, Pa., and from National Technical Information Service, Springfield, Va., PB 286 064/AS.

28. Nair, B. K., G. K. Schenck, and F. R. Demler. SIC Based End-Use Scheme for Information Critical Minerals. 1978, 584 pp.; available from Penn State Univ., University Park, Pa.

29. National Commission on Supplies and Shortages. Government and the Nation's Resources. Washington, D.C., 1976, 211 pp.

30. _____. Information Systems Studies. Washington, D.C., 1976, 454 pp.

31. National Materials Advisory Board. Contingency Plans for Chromium Utilization. National Academy of Sciences, Washington, D.C., 1978, 347 pp.

32. Newcomb, R. T. Mineral Industry Demands and General Market Equilibrium. Ch. in Economics of the Mineral Industries. American Institute of Mining, Metallurgical, and Petroleum Engineer, New York, 3d ed., 1976, pp. 271-316.

33. Office of Technology Assessment. An Assessment of Information Systems Capabilities Required To Support U.S. Materials Policy Decisions. U.S. Congress, Washington, D.C., 1976, 249 pp.

34. Organization for Economic Cooperation and Development. Information for a Changing Society. O.E.C.D. Publications, Paris, 1971, 48 pp.

35. Ridge, J. D., et al. Inter-relating Data for Technical Products With Federal Standard Industrial Classification (SIC). Report to the U.S. Bureau of Mines, Grant G0122113, available from Pa. State Univ., 1974, 196 pp.

36. Rogers, R. P. Competition in the Sulfuric Acid Industry. Federal Trade Commission, Bureau of Economics, 1977, 168 pp.

37. Schenck, G. K., and B. K. Nair. The Progress of Implementation of SIC Based Surveys. Final Report on BuMines Grant G0166213, 1979, 28 pp.; available from Pa. State Univ. and BuMines, Office of Economic Analysis.

38. Schenck, G. K., B. K. Nair, and J. Hollister. SIC Based End-Use Data Scheme for Selected Mineral Commodities. BuMines Open File Rept. 130-76, 1976, 212 pp.; available for consultation at the Bureau of Mines Libraries in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash., and at the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C.; copies available from Pa. State Univ., University Park, Pa., and from National Technical Information Service, Springfield, Va., PB 262 389.

39. Standen, Anthony (ed.). Encyclopedia of Chemical Technology. Interscience Publishers, New York, 1963, v. 1-22.

40. Stanford Research Institute. Chemical Economics Handbook. Menlo Park, Calif., 1968, 1015 pp.

41. Tilanus, C. B. Marginal Versus Average Input Coefficients in Input-Output Forecasting. Quarterly J Economics, v. 81, No. 1, 1967, pp. 140-145.

42. Tilton, J. E. The Future of Nonfuel Minerals. The Brookings Institution, Washington, D.C., 1977, 113 pp.

43. U.S. Bureau of Mines. End Uses of Sulfur and Sulfuric Acid in 1975 and 1976. Mineral Industry Surveys, 1977, 10 pp.

44. _____. Mineral Commodity Profiles (series).

45. _____. Mineral Commodity Summaries. 1978, 200 pp.

46. _____. Mineral Facts and Problems. Bull. 667, 1975, 1259 pp.

47. _____. Minerals Yearbook. 1970-74, v. 1-2.

48. U.S. Department of Commerce. Census of Manufacturers. Bureau of the Census, 1972.

49. _____. Numerical List of Manufactured Products (New 1972 SIC Basis). Bureau of the Census, 1972, 337 pp.

50. U.S. Statistical Policy Division (Office of Management and Budget). Standard Industrial Classification Manual. 1972, 649 pp.

51. United Nations Industrial Development Organization. World Sulphur Supply and Demand 1960-1980. United Nations Publications, New York, 1973, 165 pp.

52. Vogely, W. A. Is There a Law of Demand for Minerals. Earth and Mineral Sciences (Pa. State Univ.), v. 45, No. 7, 1976, pp. 49-53.

53. Vogely, W. A., and E. Bonczar. The Demand for Natural Resources Revisited. Proc. Council of Economics, AIME, 1977, pp. 141-146.

54. Wang, K. L. Inter-industry Analysis. Ch. in Economics of the Mineral Industries. American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, 3d ed., 1976, pp. 322-336.

55. Wonnacott, R. J., and T. H. Wonnacott. Econometrics. John Wiley & Sons, New York, 1970, 445 pp.

APPENDIX A.--SOME OF THE FIRMS AND TRADE ASSOCIATIONS CONSULTED IN THIS STUDY

Alcan Aluminum, Elizabeth, N.J.
Alcoa, Pittsburgh, Pa.
Allegheny Ludlum, Pittsburgh, Pa.
Allied Chemicals, Morristown, N.J.
Alpha Metals, Jersey City, N.J.
Aluminum Association, New York, N.Y.
Amax, Niagara Falls, N.Y.
American Cyanamid, Wayne, N.J.
American Electroplaters Society, Winter Park, Fla.
American Hot Dip Galvanizers Association, Washington, D.C.
American Iron and Steel Institute, Washington, D.C.
Anaconda, Greenwich, Conn.
Arconium Corp. of America, Providence, R.I.
Asarco, New York, N.Y.
Asarco, Tucson, Ariz.
Asbestos Textile Institute, Willow Grove, Pa.
Ashville-Schoomaker Mica Co., Newport News, Va.

Babcock & Wilcox, Beaver Falls, Pa.
Belmont Metals, New York, N.Y.
Beloit Corp., Beloit, Wisc.
Bismuth Institute, Brussels, Belgium

Cabot, Stellite Division, Kokomo, Ind.
Canon-Muskegon, Muskegon, Mich.
Carpenter Technologies, Reading, Pa.
Cerro Metal Products, Bellefonte, Pa.
C. F. Industries, Bartow, Fla.
Cities Service Co., Atlanta, Ga.
Cleveland Mica, Lakewood, Ohio.
Climax Chemical, Hobbs, N. Mex.
Cobalt Information Center, Columbus, Ohio
Copper Development Association, New York, N.Y.
Crucible Steel, Midland, Pa.

Delta Chemicals, Searsport, Maine
Derby, Pittsburgh, Pa.
Diamond Shamrock, Cleveland, Ohio
Duval Corp., Houston, Tex.
Economy Plating, Chicago, Ill.
E. I. du Pont de Nemours, Wilmington, Del.
Englehard, Plainville, N.J.
ESB Incorporated, Philadelphia, Pa.
Essex, Fort Wayne, Ind.
Essex Chemical Corp., Clifton, N.J.

Falconbridge, Greentree, Pa.
Fansteel Metallurgical Corp., North Chicago, Ill.
Federal Mogul, Detroit, Mich.
Ferroalloys Association, Washington, D.C.
Freeport Sulfur, New York, N.Y.

Gardiner Metal, New York, N.Y.
General Electric, Carboloy Division, Detroit, Mich.
General Electric, Magnets Division, Edmore, Mich.
General Electric, Cleveland, Ohio
Gould Inc., St. Paul, Minn.
GTE Sylvania, Towanda, Pa.
Gulf and Western Industries, Bethlehem, Pa.
Gulf Oil Corp., Houston, Tex.
Gulf Resources and Chemical Corp., Gastonia, N.C.

Hall Chemicals, Cleveland, Ohio
Hammond Lead Products, Hammond, Ind.
Handy & Harman, New York, N.Y.
Harshaw Chemical, Cleveland, Ohio
Hewitt Metals, Detroit, Mich.
Howmet Turbine Components, Pontiac, Mich.
Huntington Alloys, Huntington, W. Va.

Indiana General, Valparaiso, Ind.
Indium Corp. of America, Utica, N.Y.
Inspiration Consolidated Copper, Inspiration, Ariz.
International Nickel, New York, N.Y.
International Minerals and Chemical, Libertyville, Ill.

Johns Manville, Denver, Colo.
Jones & Laughlin Steel, Pittsburgh, Pa.

Kaiser Aluminum & Chemical, Oakland, Calif.
Kennametal, Latrobe, Pa.
Kennecott Copper, New York, N.Y.
Kerr McGee Chemical Corp., Oklahoma City, Okla.
Kester Solder, Chicago, Ill.
Kraft Chemicals, Chicago, Ill.

Lead Industries Association, New York, N.Y.
Li Tungsten Corp., Glen Cove, N.Y.

Magma Copper, San Manuel, Ariz.
Magnetics Specialty Metals, Butler, Pa.
Metal Finishing Suppliers Association, Birmingham, Mich.
Midwest Mica & Insulation, Cleveland, Ohio
Minnesota Mining and Manufacturing, St. Paul, Minn.
Mobil Oil, Depue, Ill.
Monsanto, St. Louis, Mo.

National Association of Metal Finishers, Montclair, N.J.
National Steel, Weirton, W. Va.
National Zinc, Bartlesville, Okla.
New Jersey Zinc, Gloucester, N.J.
Nicolet, Ambler, Pa.
N. L. Industries, New York, N.Y.
N. L. Industries, Hightstown, N.J.
Nonotuck Manufacturing, Shadly Falls, Mass.

Occidental Petroleum, Niagara Falls, N.Y.
Olin Corporation, Stamford, Conn.
Ozark-Mahoning, Tulsa, Okla.

Pennwalt Corp., Philadelphia, Pa.
Phelps-Dodge, New York, N.Y.
Pfizer, Easton, Pa.

Raybestos-Manhattan, Turnbull, Conn.
Reactive Metals Inc., Niles, Ohio
Read & Barton, Taunton, Mass.
Refractory Association, Pittsburgh, Pa.
Remington Arms, Bridgeport, Conn.
Republic Metals, New York, N.Y.
Reynolds Aluminum, Richmond, Va.
Reynolds Chemicals, Richmond, Va.
Rohm and Haas, Philadelphia, Pa.
RSR Corp., Dallas, Tex.

Silver Institute, Washington, D.C.
Southwire, Carrolton, Ga.
St. Joe Minerals, New York, N.Y.
Standard Oil of California, El Segundo, Calif.
Standard Oil of Indiana, Texas City, Tex.
Stauffer Chemicals, Westport, Conn.
Steel Service Center Institute, Cleveland, Ohio
Sunshine Mining, Kellogg, Idaho

Talco, Philadelphia, Pa.
Tantalum Producers Association, Cleveland, Ohio
Texaco, Houston, Tex.
Texas Gulf, New York, N.Y.
Thomas & Skinner, Pittsburgh, Pa.
Tin Research Institute, Columbus, Ohio
Titanium Metal Corp. of American, Pittsburgh, Pa.

Udylite Corp., Warren, Mich.
United Refining & Smelting, Franklin Park, Ill.
Union Carbide, New York, N.Y.
United Technology, Essex Group, Newmarket, N.H.
U.S. Industrial Chemicals, New York, N.Y.
U.S. Steel, Pittsburgh, Pa.
USS Agri-Chemicals, Bartow, Fla.

Western Electric, New York, N.Y.
Williams Companies, Tulsa, Okla.
W. R. Grace, Memphis, Tenn.
Wright Chemical Corporation, Riegelwood, N.C.

Zinc Institute, New York, N.Y.

APPENDIX B.--REFERENCES TO COMMODITY STUDIES

Commodity	Source agency for data and Penn State reference[1]
Alumina	U.S. Bureau of Mines (28).
Aluminum metal	Aluminum Association (38).
Antimony	U.S. Bureau of Mines (28).
Asbestos	Do.
Bismuth	Do.
Cadmium	Do.
Chromium:[2]	
Compounds	Do.
Refractories	Do.
Cobalt:[2] Compounds	Do.
Columbium-Tantalum	Do.
Copper:	
Brass	Copper Development Association (28).
Wire mill products	U.S. Department of Commerce (28).
Fluorine:	
Fluorspar	U.S. Bureau of Mines (38).
Fluosilicic acid	Do.
Hydrofluoric acid	Do.
High-temperature alloys	U.S. Bureau of Mines (28).
Carbides and hardfacing alloys	Do.
Magnetic alloys	Do.
Lead	Do.
Magnesium:	
Compounds	Do.
Metal	Do.
Mercury	Do.
Mica	Do.
Nickel:[2]	
Special nickel alloys	U.S. Bureau of Mines (28).
Nickel electroplating	Do.
Nickel compounds	Do.
Rare earths	Do.
Silver	Do.
Steels:	
Carbon	American Iron and Steel Institute (38).
Alloy	Do.
High strength, low-alloy	Do.
Tool	Do.
Stainless	Do.
Service centers	None (28).
Sulfur:	
Elemental	U.S. Bureau of Mines (38).
Sulfuric acid	Do.
Tin	U.S. Bureau of Mines (28).
Titanium:	
Pigments	Do.
Metal and alloys	Do.
Tungsten	Do.
Vanadium	Do.
Zinc:	
Die castings	Zinc Institute (38).
Hot-dip galvanized steel	Do.
Zinc compounds	Do.
Rolled zinc	Do.

[1]In parentheses; for full citation, see entry in bibliography preceding the appendixes.

[2]See also high-temperature alloys, carbides and hardfacing alloys, magnetic alloys, and steels.

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